ASTM BULLETIN

260 SOUTH BROAD STREET PHILADELPHIA, PA.

"Promotion of Knowledge of Materials of Engineering and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENnypacker 3545 CABLE ADDRESS—TESTING

Number 99 August, 1939

Much Important Work Accomplished at Annual Meeting

Standardization Activities Particularly Prominent

WITH more actions being taken on standards than at any other meeting and with a registered attendance of members, committee members and visitors second only to the meeting in New York two years ago, the Forty-second Annual Meeting of the Society held in Atlantic City, June 26 to 30, was noteworthy. The registration of 1354 has been exceeded only by the attendance of 1523 at New York in 1937, the latter figure being augmented by a larger than the average number of visitors.

The registration consisted of 921 members, 202 committee members, and 231 visitors, the number of members and visitors each being about 100 more than at the 1938 meeting also held in Atlantic City. In addition to the men registered at the meeting, there were over 300 ladies registered, the largest number at any meeting, and also other visitors who came to the meeting primarily to visit the Fifth Exhibit of Testing Apparatus and Related Equipment. Neither the number of ladies nor exhibit visitors and exhibitors' representatives is included in the registration figure.

Throughout the week of the meeting, there were about 250 meetings of committees and in the 22 sessions (including several round-table discussions) some 122 papers and reports were presented. The program was unique in having so many round-table get-togethers covering effect of subatmospheric temperatures on metals, methods and technique of spectrochemical analysis, freezing-and-thawing tests, etc. Two extensive collections of papers were presented in symposiums covering paint testing and shear testing of soils.

Since this is the year when the Society will issue its triennially published Book of Standards, it was expected the intense activity of committees would result in many recommendations. All told, some 107 existing tentative specifications were recommended for adoption as standard, and revisions of standards which had been published previously for consideration are to be referred to letter ballot for adoption in over 110 standards. These figures are more than three times the corresponding statistics for 1938 and exceed by about 50 per cent the last comparable year, namely, 1936. Despite activity on standards, there was very little diminution in the number of new specifications and tests recommended for publication as tentative. This figure of 56 has been exceeded only by the 1938 figure of 71. A chart dis-

Greystone Studios

New President
H. H. Morgan

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New Vice-President
G. E. F. Lundell

played during the opening session of the meeting showed the very decided upward trend in the Society's standardization activities.

The accompanying table arranged according to the general materials fields involved summarizes the recommendations acted upon at the annual meeting. In a separate mailing there is being sent to each member a letter ballot covering those actions involving the adoption of new standards or changes in existing ones, this ballot being accompanied as customary by the Summary of Proceedings which gives detailed information on matters covered in the ballot.

A list of new tentative standards appears on another page of this BULLETIN and there is also an article listing the standards which were withdrawn for various reasons, in many cases because of replacement or consolidation with other standards.

In conjunction with the meeting, there was sponsored the Fifth Exhibit of Testing Apparatus and Related Equipment, with a large number of new items displayed for the first time. Several Society committees and a number of government and research institutions participated with special exhibits. The Society's Second Photographic Exhibit created considerable interest. Both the Section on Photomicrography and the General Section included many splendid examples. Over 200 prints were submitted. General discussions of the Apparatus and Photographic Exhibits appear on another page of this BULLETIN.

PRESIDENTIAL ADDRESS

The President, Dr. T. G. Delbridge, presented as his presidential address, "Glimpses at Petroleum," giving concisely a general picture of the development of this great industry and illustrating its importance among American industries. The address was given at the formal opening session on Tuesday. In paying tribute to the work of the Society and the help it has rendered to the industry, he called attention to the fact that the petroleum industry was not only concerned with the Society's work from the standpoint of producers but that the producing, refining, transportation and marketing branches are sizeable consumers of nearly all materials now within the scope of A.S.T.M. As a producer, the industry is somewhat unique in A.S.T.M. since many of its products are of direct personal interest to the individual consumer.

In the constant extension of better products at lower prices he indicated the attention and support given research as a vital factor and mentioned that the Society had again and again been the coordinator of research, argument, experimentation and collaboration which has led to universal benefit to the ultimate consumer.

MARBURG LECTURE

A most interesting Fourteenth Edgar Marburg Lecture was delivered by H. F. Moore, Professor of Engineering Materials, University of Illinois, on the subject "Stress, Strain and Structural Damage." After indicating that materials of construction are not homogeneous, and that actually in all materials, at least all common structural ones, there are always minute areas of high stress, he stated his belief that if it were not for the relief of stress by localized inelastic action, it would be very doubtful whether our structural and machine parts would stand up in service. Structural damage to material, at least, that caused by static loads rarely ever takes place until an appreciable volume of material is involved—a volume comprising thousands of grains or of fibers, hundreds of thousands of space lattice cells, and millions of atoms. . . . This makes it seem that statistical methods might be useful guides, and since no better theory has yet been developed than the mathematical theory of elasticity and since it may be regarded as statistically true when applied to actual materials, he proposed to retain it and use it until a better method has been demonstrated. He said, "I believe this attitude is typical of the applied scientist. I believe it to be an attitude not only justifiable but praiseworthy in our reactions to the actual problems of materials and of life. I recognize the danger of becoming too insensitive to really better fundamental assumptions and the theories built on them, but after all that is considered, I respectfully call the attention of the traditional learned professions to this attitude, and humbly suggest that it is worthy of consideration."

He considered four types of structural damage due to mechanical causes: (1) elastic deformation, (2) damage by inelastic action, (3) fracture, and (4) damage by continuing deformation or "creep." He felt it advisable to limit discussion to these four types and not to consider subjects of corrosion fatigue, impact, wear, etc. He pointed out that in considering fractures it is natural to think of them as occurring "all at once and nothing first" but stated that the high-speed camera shows that neither bubbles nor pieces of wood or metal fracture "all at once." They fracture progressively, but in some cases so rapidly that the eye cannot follow the progress of the spreading crack. He indicated that the only tests for resistance to creep that seem at all reliable were those involving direct measurement over a time of at least 1000 hr. In connection with fatigue tests, he sounded a warning not to put confidence in short-time fatigue tests.

SUMMARY OF ACTIONS TAKEN AT ANNUAL MEETING AFFECTING STANDARDS AND TENTATIVE STANDARDS

	Existing Tentative Standards Adopted as Standard	Standards in Which Revisions Will Be Adopted	New Tentative Standards	Proposed Revisions of Existing Standards Accepted as Tentative	Existing Tentative Standards Revised	Standards and Tentative Standards Withdrawn or Replaced	Total Standards Adopted	Total Tentative Standards
A. Ferrous Metals—Steel, Cast Iron, Wrought Iron, Alloys, etc.	18	45	9	4	10	19	133	35
B. Non-Ferrous Metals—Copper, Zinc, Lead, Aluminum, Alloys, etc.	8	15	16	2	10	8	54	61
C. Cement, Lime, Gypsum, Concrete and Clay Products	22	22	3	3	9	5	105	28
D. Paints, Petroleum Products, Paper, Textiles, Rubber, Soap, etc.	56	35	26	13	25	33	273	141
E. Miscellaneous Subjects, Testing, etc.	3	1	2	..	1	1	14	15
Total	107	118	56	22	55	66	579	280

From left to right: President-elect H. H. Morgan; H. F. Moore, Marburg Lecturer; R. W. Carlson, Dudley Medalist; President T. G. Delbridge; C. L. Warwick, Secretary-Treasurer.

DUDLEY MEDAL AWARD

In presenting the winner of the Charles B. Dudley Medal for 1939 to the President at the session on Wednesday afternoon, Prof. M. F. Sayre, Union College, chairman of the Dudley Medal Award Committee, spoke as follows:

"Thirteen years ago this Society initiated an award in memory of a man who had been actively concerned in the founding of the Society and largely responsible for its growth through many years. This award, in recognition of one of the basic interests of Charles B. Dudley, was to be given annually to the author or authors of a paper of outstanding merit constituting an original contribution on research in engineering materials, presented before the Society during the preceding year.

"I did not personally know Doctor Dudley, except casually, but from the slight knowledge I feel that for an award of this kind he would have demanded a clear thinking analysis of the subject under investigation, an elimination of non-essentials and an emphasis upon essentials; and I feel that he would have placed considerable emphasis upon a desire that the result obtained should have been of definite tangible benefit to human progress. Your committee feels that the paper presented by Roy W. Carlson last year upon the subject 'The Drying Shrinkage of Concrete as Affected by Many Factors,' in which after studying and discarding other factors he lays emphasis upon the character of the aggregate as being the main factor in determining the amount of shrinkage in concrete structures, satisfies each of these requirements.

"Mr. Carlson, in somewhat bashful manner, calls this only a progress report; but your committee feels that for this 'progress report' he well deserves this year's Dudley Medal Award. Mr. President, it gives me great pleasure to present to you Roy W. Carlson, a physicist turned engineer, graduate in 1922 of the University of Redlands in California, graduate student in physics at California Institute of Technology, engaged in cement research at the University of California in connection with the Boulder Dam, now Associate Professor of Civil Engineering at the Massachusetts Institute of Technology, and only a few days ago honored by the degree of Doctor of Science by that institution, and to recommend him for the Dudley Medal Award."

GOLF TOURNAMENT

Despite inclement weather, the Twenty-second Annual Golf Tournament went off as scheduled on Thursday afternoon at the Seaview Golf Club, where most of the Atlantic City tournaments have been held, through the courtesy of G. H. Clamer, member of the club. This year particular interest was centered in the new A.S.T.M. golf cup which was put up for competition by the Climax Molybdenum Co., whose vice-president, C. M. Loeb, had retired in 1938 the previous cup which had been in competition for many years. The honor of keeping the cup for a year went to V. A. Crosby for his low gross score. In addition to the cup, he won nine golf balls. G. W. Hutchinson won second low gross and his prize consisted of nine balls. For the low net and kickers event, there were triple ties in each case, the former being won on a draw by A. Stewart who took six golf balls, and the latter by G. H. Clamer, who was awarded a dozen golf balls. Gross scores ranged from the low 80's to 105. The tournament was in the charge of the committee consisting of Harold Farmer and G. H. Clamer.

While the turnout of golfers was excellent considering the weather, plans are under way to stimulate even more interest in this event for next year. Further announcements will be made.

CHANGES IN REPORTS

Several of the committees which reported at the annual meeting submitted modifications of their reports, and in certain cases made additional recommendations not covered in the preprinted reports. While full details of all actions taken at the meeting are included in the Summary of Proceedings being sent to each member under separate cover, attention is called to a few of the changes. The Steel Committee withdrew its recommendation to adopt as standard consolidated specifications covering carbon-steel forgings and instead will submit this as tentative through Committee E-10 on Standards, at the same time recommending that the existing standard A 18 which covers both carbon and alloy steels, continue as standard. A clause providing certain requirements for structural bolts is to be added to the consolidated specifications for steel for bridges and buildings (A 7).

The recommendation by Committee C-1 on Cement for a new tentative test for autoclave expansion of portland cement on which there has been extended discussion for the past two years was defeated in the annual meeting session. Committee C-12 on Mortars for Unit Masonry withdrew two of the items in its report, namely, the primer on specifications and tests for masonry mortar and the proposed specifications for mortar. A doctor test for motor fuels which appeared in the preprint of Committee D-2 on Petroleum Products and Lubricants was withdrawn, and certain additional recommendations were made including the adoption of the tentative standard viscosity temperature charts, the method for con-

Left to right: H. M. Millburn, E. E. Scholer, Prevost Hubbard, J. S. Sawyer.

Paul Ffield and H. H. Lester

L. L. Wyman, T. S. Fuller, E. N. Downing

version of kinematic viscosity to Saybolt and tentative definitions of terms relating to petroleum. A proposal by Committee B-4 that the method of bend testing of wire (wire for radio tubes and incandescent lamps) be adopted as standard was withdrawn.

Among other important matters not covered in preprints was the action of Committee A-9 on Ferro Alloys in recommending for adoption as standard revised specifications covering ferrotungsten, ferromolybdenum, molybdenum salts and compounds, ferromanganese, ferrovanadium, ferrosilicon. Revisions proposed in the standards for spiegeleisen and ferrochromium were accepted for publication as tentative.

Certain other changes and additions were acted upon and full details are given in the Summary of Proceedings which should be consulted.

OUTSTANDING REPORTS

While all of the reports of standing committees were of importance, particularly to the specific fields covered, and many of them included very important recommendations on standardization, there were a few outstanding. The report of Committee A-5 on Corrosion of Iron and Steel, which was this year's most extensive one (110 pages), was notable because it gave data on the original characteristics of the wire and wire products involved in its extensive field tests, and in addition to these 55 pages of data, there were given the results of the atmospheric corrosion tests after exposure of about two years at each of the eleven locations.

The extensive report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys included results of atmospheric corrosion tests on galvanic couples over a seven-year period as well as results of preliminary tests of galvanic couples exposed in sea water and some preliminary tests of stainless steel coupled with non-ferrous metals exposed to salt spray.

Committee A-1 on Steel in its voluminous report offered five new tentative specifications, three covering castings suitable for fusion welding; two at high-temperature service, the other for miscellaneous industrial uses. Another action was considered of much importance, namely, the new consolidated standard covering structural steel for bridges and buildings (A 7), a consolidation of the specifications for bridges (A 7) and the specifications for buildings (A 9).

Ten existing tentative specifications covering various types of chromium and chromium-nickel castings were recommended for adoption as standard by Committee A-10 on Iron-Chromium-Nickel and Related Alloys.

Among the recommendations in the extensive report submitted by Committee B-5 on Copper and Copper Alloys, Cast and Wrought, were six new tentative standards covering the following: leaded brass sheet and strip; copper-nickel and copper-nickel-zinc alloy sheet and strip; beryllium copper bars, rods, sheets, strip, and wire; copper-base-alloy forging rods; nickel-silver sand casting alloys; and classification of cast copper-base alloys.

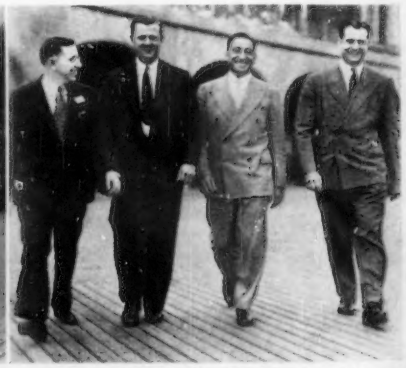
TECHNICAL SESSIONS

The large number of items presented at the meeting, some 122 papers and reports, makes it virtually impossible to re-

(*Continued on page 8*)

R. C. Griffin, James d'A. Clark, R. G. MacDonald, John Hagar

C. A. Neusbaum, E. W. Dean, R. P. Anderson



A. J. Herzig, P. M. Snyder, C. M. Loeb, Jr., T. D. Parker

M. A. Swayze J. J. Allen R. D. Bonney J. L. McCloud T. S. Fuller

NEW OFFICERS

THE recent election of officers, as announced at the annual meeting by the tellers resulted in the unanimous election of H. H. Morgan as President (1939-1940), G. E. F. Lundell as Vice-President (1939-1941) and the following as members of the Executive Committee (1939-1941): J. J. Allen, R. D. Bonney, T. S. Fuller, J. L. McCloud and M. A. Swayze.

PRESIDENT

H. H. Morgan, the new President, Manager, Rail and Tract Fastening Dept., Robert W. Hunt Co., Chicago, Ill., has been connected with this company since 1904, when he was graduated from Lewis Institute, Chicago, with the degree of Mechanical Engineer. Consequently he has been closely connected with testing, inspection, and research problems in the field of materials. Beginning in 1907, he was in charge of miscellaneous inspection for his company. In 1910 he became Manager, Physical Testing Laboratories, serving in this capacity until 1917; also from 1912 to 1917 he was Manager of the Hunt Cement Testing Laboratories. During the period of the war, 1917-1918, he represented his company on war materials inspection for the Engineer Corps, U.S.A., becoming Captain. For the next ten years he was Manager of the Pittsburgh Office and District of his company and since 1928 has been in his present position.

Mr. Morgan has been very active in A.S.T.M. affairs and in the work of other groups. From 1932 through 1938, he was chairman of Committee A-1 on Steel and previously headed its subcommittees on pipe and tubing materials and on reinforcing steel. He is a member of Committees A-9 on Ferro-Alloys and E-1 on Methods of Testing. Since 1938 he has served as one of the A.S.T.M. representatives on the Standards Council of the American Standards Association and is chairman of Sectional Committee B36 on Standardization of Dimensions and Materials of Wrought-Iron and Wrought-Steel Pipe and Tubing. He also is the A.S.T.M. representative on the A.S.A. Mechanical Standards Committee. A member of the A.S.T.M. Executive Committee, 1935 to 1937, he became Vice-President in 1937, his term expiring in June of this year. His other society affiliations include The American Society of Mechanical Engineers, American Society for Metals, Western Society of Engineers, and American Railway Engineering Association. He is also a member of the Skokie Country Club. Mr. Morgan's residence is in Glencoe, Ill.

VICE-PRESIDENT

G. E. F. Lundell, the new Vice-President, Chief, Chemistry Division, National Bureau of Standards, Washington, D. C., received his A.B. degree from Cornell University, 1903, and his Ph.D. degree in 1909. From 1903 to 1906 he was instructor in chemistry at Northwestern University and, until 1917, Assistant Professor at Cornell. He then became Chemist, National Bureau of Standards in Washington, and in 1936, was appointed Assistant Chief Chemist, becoming Chief Chemist in 1937. He is chiefly concerned with the analysis of rocks, ores, ceramics, and metallurgical materials and is in charge of the preparation and analysis of the Bureau's standard analyzed samples.

He is a member of several A.S.T.M. committees, including A-2 on Wrought Iron, A-3 on Cast Iron, A-9 on Ferro-Alloys, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, B-2 on Non-Ferrous Metals and Alloys, B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys, and E-1 on Methods of Testing. He is chairman of Committee E-3 on Chemical Analysis of Metals and of Subcommittee II on Chemical Analysis of Committee C-14 on Glass and Glass Products. A member of the Society since 1918, he is completing a term as a member of the Executive Committee which began in 1937. Dr. Lundell is also active in the work of other groups, is Councilor of the American Chemical Society and Associate Editor of its journal, and chairman of the Board of Editors of the Analytical Edition of *Industrial and Engineering Chemistry*. He is a member of the American Ceramic Society—chairman of the Editorial Committee of the Glass Division.

MEMBERS OF EXECUTIVE COMMITTEE

J. J. Allen, Chief Chemist, Mechanical Rubber Goods Division, Firestone Tire and Rubber Co., Akron, Ohio, following his graduation from Case School of Applied Science in 1922 with the degree of B.S. in Chemical Engineering, was employed at the Mechanical Rubber Co., Cleveland, Ohio, from 1922 to 1925, and then until 1927 he was with this company in Chicago. He has been affiliated with his present company since 1927. In 1929 he received the degree of Master of Science, and in 1931 the degree of Chemical Engineer—both from Case. He has been active in the work of the Society for many years, particularly Committee D-11 on Rubber Products and several of its subcommittees, and is chairman of Subcommittee XVII on Rubber Products for

Absorbing Vibration. He also represents Committee D-11 on the Section on Indentation Hardness of Committee E-1 on Methods of Testing. He is a former member of the Akron Division of the A.S.T.M. Cleveland District Committee. Mr. Allen is a member of the American Chemical Society and the Alpha Chi Sigma (Chemical) and Tau Beta Pi (Engineering) fraternities.

R. D. Bonney, Assistant Manager of Manufacturing, Congoleum-Nairn, Inc., Kearny, N. J., received his degree of B.S. in Chemical Engineering in 1913 at Massachusetts Institute of Technology. He spent two years in graduate study, during which period he was also instructor in analytical chemistry. From 1915 to 1918 he was chemist at Bird and Son, and in 1918 became affiliated with the Congoleum Company as chief chemist, Marcus Hook. From 1924 to 1927 he was chief chemist of Congoleum-Nairn, Inc., Philadelphia, later becoming director of research, Kearny, N. J. In 1934 he was appointed to the position he now holds. In the Society he has been active in the work of Committee D-1 on Paint, Varnish, Lacquer, and Related Products and is a former member of Committee D-2 on Petroleum Products and Lubricants. He is also a member of Committee D-6 on Paper and Paper Products. Mr. Bonney is active in the work of numerous other Societies, including the American Chemical Society, American Institute of Chemists, and New York Paint and Varnish Production Club (Past-President of the Philadelphia Paint and Varnish Club).

T. S. Fuller, Engineer of Materials, Schenectady Works Laboratory, General Electric Co., Schenectady, N. Y., was graduated from Syracuse University in 1911 with the degree of B.S. in Chemistry. He began his career with the General Electric Co. as a member of the Research Laboratory in 1911 and became Engineer of Materials in the Works Laboratory in 1938. Mr. Fuller has been very active on several A.S.T.M. committees, in particular Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys, of which he has been chairman continuously since 1927. During this time the committee inaugurated some of the most extensive corrosion tests yet undertaken. For many years he has been a member of the Research Committee on Fatigue of Metals, Committee B-2 on Non-Ferrous Metals and Alloys, and at the present time he represents his company on more than 20 other standing committees. He has written many papers on metals and alloys. He is a member of the American Institute of Mining and Metallurgical Engineers, British Institute of Metals, and the American Society for Metals.

J. L. McCloud, Metallurgical Chemist, Ford Motor Co., Dearborn, Mich., a graduate of the University of Michigan, class of 1913 with the degree of Bachelor of Chemical Engineering, in his senior year was assistant to Dr. Gomberg, Professor of Organic Chemistry. Following this he was employed by the U. S. Rubber Co. at their Morgan and Wright Plant. Since 1915 he has been with the Ford Motor Company. For the period 1917 to 1920 he was chief chemist with Henry Ford and Son, manufacturing tractors. When the company was manufacturing airplanes he served as chemist and metallurgist for that division. Since 1928 he has been in charge of paint formulation, specifications and application. Mr. McCloud is affiliated with many phases of A.S.T.M. work and for many years he has been a member of Committee D-1 on Paint, Varnish, Lacquer, and Related Products and Committee D-2 on Petroleum Products and Lubricants. He is chairman of the D-2 subcommittee on pour point and viscosity. A member of the Detroit District Committee since 1935 he is at present Vice-Chairman. He has written numerous papers and reports on metals, oil requirements, and paint coatings.

M. A. Swayze, Director of Research, Lone Star Cement Corp., Hudson, N. Y., has been concerned with the fields of cement and concrete since 1912 when he was graduated with the degree of B.S. in Chemical Engineering from Case School of Applied Science. (Degree of Ch.E. in 1918, Case.) He was first with the Crescent Portland Cement Co. From 1913 to 1921 he was assistant and later chief chemist at the Houston Plant, Texas Portland Cement Co. Then until 1929 he was chief chemist, the Lone Star Cement Co., at Hudson, N. Y. Later he became assistant and chief chemist of the International Cement System, which position he held until 1932 when he became chief chemist and research engineer of the Lone Star Cement Company. In 1938 he became the Director of Research. Mr. Swayze has been very active in the work of Committee C-1 and is chairman of the high-early-strength cement subcommittee. He represents the Portland Cement Association on the Joint Committee on Concrete and Reinforced Concrete and is a member of the Technical Problems Committee of the P.C.A. He is a member of the Committee on Research of the American Concrete Institute.

Fifth Apparatus Exhibit, First At Atlantic City, Interesting

Many New Instruments Shown for First Time; Research and Committee Displays Educational

JUDGING from the comments of many of the members and visitors who inspected the Society's Fifth Exhibit of Testing Apparatus and Related Equipment held throughout the five days of the Forty-second Annual Meeting, and from exhibitors' reactions it was an extremely worthwhile and successful one. Displays sponsored by the companies in the apparatus and laboratory supply industries were well designed with capable representatives on duty. Throughout the week there was an excellent attendance morning and afternoon and during the two evenings when it was open. Two of the hotel's large function rooms were used to provide the necessary space.

During the interval of two years between Exhibits there are many important developments in the field of testing apparatus and related equipment. Perhaps the outstanding general feature of the 1939 Exhibit was the large number of new instruments and apparatus displayed for the first time, much of the apparatus involving many of the fields in

which the Society is active. There were notable developments in the field of spectrography and physical testing and also in connection with many other laboratory supplies and instruments.

The following companies took part in the commercial section of the exhibit:

American Instrument Co.
Baldwin-Southwark Corp.
Bausch & Lomb Optical Co.
Christian Becker, Inc.
Brabender Corp.
Central Scientific Co.
Eimer & Amend.
The Electric Tachometer Corp.
Federal Products Corp.
Henry A. Gardner Laboratory, Inc.
C. E. Hoover.
Kimble Glass Co.
Leeds & Northrup Co.
"Metals and Alloys."
National Carbon Co., Inc.
Nurnberg Thermometer Co., Inc.
Tinius Olsen Testing Machine Co.
Parr Instrument Co.
E. W. Pike & Co.
Radium Chemical Co., Inc.
Riehle Testing Machine Division American Machine and Metals, Inc.
Rubicon Company.
George Scherr Co.
Henry L. Scott Co.
C. J. Tagliabue Manufacturing Co.
Carl Zeiss, Inc.

From the beginning technical and scientific aspects of instrumentation work in the field of materials have been stressed, and displays sponsored by various research laboratories, institutions, and Society committees have added greatly to this end. This year two research displays in particular, those of the National Bureau of Standards and the U. S. Bureau of Mines were very attractive and educational. Certain work of Bell Telephone Laboratories and also Princeton University attracted interest.

Committees sponsoring displays in the exhibit included the following:

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys (Subcommittee VIII on Galvanic and Electrolytic Corrosion).
Committee C-5 on Fire Tests of Materials and Construction.
Committee D-1 on Paint, Varnish, Lacquer, and Related Products.
Committee D-17 on Naval Stores.
Committee D-18 on Soils for Engineering Purposes.
Committee E-2 on Spectrographic Analysis.
Committee E-4 on Metallography.
Committee E-7 on Radiographic Testing.

The display of Committee B-3 arranged by L. J. Gorman, Chairman of Subcommittee VIII, was extremely interesting giving a good conception of the importance of this work, stressing in particular the work on galvanic and electrolytic corrosion. Photographs and other material supplemented displays of actual samples of corrosion test specimens. A fire test tube with charts and descriptive material, also transparencies showing time-temperature curve with colors, temperatures obtained in fire tests of partitions, ship construction and floors were included in the display of Committee C-5. Committee D-1 displayed a hydrometer reading in direct pounds per gallon of turpentine with temperature correction tables, and also showed a number of typical panels on which gloss measurements had been made in accordance with the new method of test for specular gloss of paint finishes. Committee members and visitors were asked to make their classifications, the resulting data to be studied by the committee. A photoelectric photometer for measuring the chromaticity and brightness of rosin colors as a basis for grading was included in the display of Committee D-17 on Naval Stores.

Supplementing the Symposium on Shear Testing of Soils was a display sponsored by Committee D-18 including a number of testing machines and several photographs and charts illustrating different machines used in this work. A display of super-pure metals and other information of importance to all those concerned with the field of spectrography and chemical analysis was developed by Committee E-2 and proved to be of considerable interest, particularly in view of the Round-Table Discussion on Spectrochemical Analysis.

A special exhibit committee headed by H. E. Seemann arranged a very interesting display of X-ray and gamma-ray radiographs for Committee E-7 on Radiographic Testing. Special viewing cabinets were furnished through the courtesy of the Eastman Kodak Co. Among the features were a group of radiographs selected from the set of the United States Navy Standards.

Committee E-4 was responsible for the section on photomicrography in the photographic exhibit—many of the E-4 members having submitted prints. In the A.S.T.M. booth were displayed sets of A.S.T.M. publications, photographs of charter members, diagrams showing the progress of the Society, and other material of interest to members and visitors.

General Views of Part of the Exhibit

Cloyd M. Chapman and Harvey Whipple

G. W. Morey and Louis Navias

W. C. Hamilton and H. J. French

view adequately in the space available individual items. Furthermore, members have had the opportunity to obtain preprints and the material presented, including discussion, will be published in the 1939 *Proceedings,* to be sent to each member late in the year. Some mention can be made, however, of outstanding groups of papers and reports, all of which attracted considerable interest. This includes the Symposium on Paint Testing sponsored by Committee D-1 including eleven informal technical papers and discussions on such topics as measuring gloss, testing elasticity and hardness, texture, stability of dipping coatings, heat resistance, bending tests, consistency and the like. These items were not preprinted.

The session on water, including five technical papers, was marked by a very interesting discussion on some of the problems involved, this discussion clarifying a number of important points in the papers.

Distinctive features of the meeting were certain round-table discussions, including the one on effect of sub-atmospheric temperatures on the properties of metals and the discussion on fundamental methods and technique of spectrochemical analysis, the latter covering both morning and afternoon periods. The first-named discussion was sponsored by the Joint Committee on Effect of Temperature on the Properties of Metals, informal discussion being preceded by two papers, one dealing with Charpy relationships, the other, factors affecting notched-bar impact tests. Discussions then followed on steel, aircraft metals, copper and copper alloys, and non-ferrous metals, leading authorities submitting prepared comments.

The extremely interesting session on spectrochemical analysis covered fundamental methods, methods of excitation, and methods of spectrophotometry, with free discussion, and with many questions and answers. The intensive interest in this subject was definitely evidenced by the enthusiasm during the round table.

Another round table was held on freezing-and-thawing tests with an excellent attendance. Many authorities in this field participated, the session extending over several hours. It was the conclusion of this round table and also of the conference on accelerated weathering tests, that the Society should undertake through appropriate committees organized work to result in the development of reliable data and the establishment of recognized test procedures. Several papers on fatigue and corrosion in the sixth session were of special interest to the ferrous and non-ferrous metals groups concerned with this work.

One session had been planned on the subject of metallography, magnetic testing, radiography, but to permit more time for discussion this was split. The group concerned with radiography met concurrently with the other. Four papers on radiography were presented.

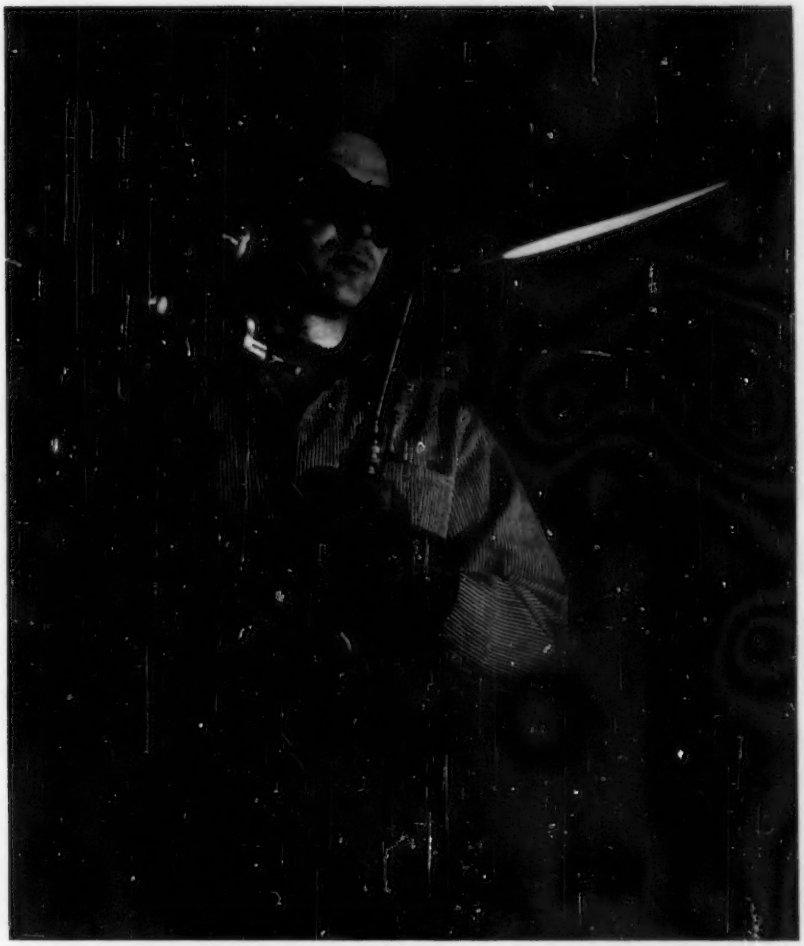
One of the interesting papers in the session on metallography involved metallography in color by R. P. Loveland, Eastman Kodak Co. A large number of illustrations were used including many colored photomicrographs demonstrating the technique and value of this rapidly developed phase.

The three sessions on the closing day of the meeting, Friday, were of interest to the particular groups concerned, two involving the field of cement, lime, gypsum and concrete—one Friday afternoon session being devoted entirely to concrete. There were two papers on determination of specific surface and particle size dealing with new apparatus and technique, and six papers covering various aspects of concrete and concrete aggregates, these being in addition to the four papers appended to the report of Committee C-9. The closing session covered non-ferrous metals and chemical analysis, with eight committee reports and three technical papers, not including two appended to the report of Committee B-5 on Copper and Copper Alloys.

N. L. Mochel and H. C. Cross

W. L. Collins, A. N. Talbot, H. J. Gilkey

W. H. Whitcomb and H. J. Ball



"The Oxy-Acetylene Torch—An Indispensable Tool in Engineering Research."

First prize winning photograph in the A.S.T.M. Photographic Competition, by C. A. Barnes, Battelle Memorial Institute.

Interesting Photographic Exhibition and Competition Held

ONE of the very interesting features of the annual meeting was the Second Photographic Exhibition and Competition on the subject "Testing and Research in Engineering Materials." Comments of the members following the first exhibition held in 1938 indicated a very definite interest in photography and the decision to sponsor another at the 1939 meeting was the logical conclusion. However, the very splendid response from members and others was unexpected, and the number of prints, over 200, made a very pleasing setup.

Various details in connection with the exhibition were handled by a special committee of men concerned with photography, as follows:

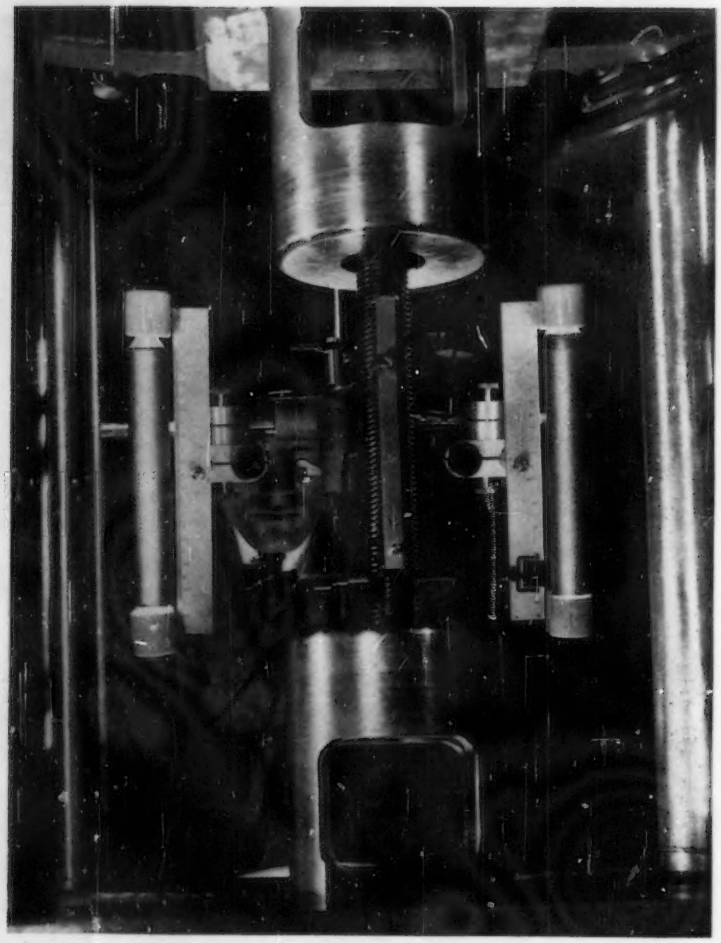
J. P. Eldridge, *chairman,* Leeds & Northrup Co.
E. L. Hettinger, Willson Products, Inc.
B. L. Lewis, E. J. McAleer & Co.
R. P. Loveland, Eastman Kodak Co.
J. P. Mudd, The Midvale Co.

There were two sections—a General Section and a Photomicrographic Section, the latter being developed under the auspices of Committee E-4, R. P. Loveland who represented that committee, being in charge.

A considerable amount of time and effort was expended by these men in connection with the exhibit and the many commendations from those at the annual meeting bespeaks the excellent way in which it was handled. The photographs in the General Section were judged by the members of the Photographic Committee, and associated with Mr. Loveland in the selection of winning prints in the Photomicrographic Section were other authorities in this field. The winners in the General Section, amateur class, were: First prize, "The Oxy-Acetylene Torch," entered by C. A. Barnes, Battelle Memorial Institute; second prize, "Proportional Limit Test on Fully Threaded Stud," W. W. Crawford, Edward Valve and Manufacturing Co., Inc. Honorable mention was given the picture, "Miscible?" by C. A. Downing, Municipal Testing Laboratory, City of St. Louis, and "Hardness of Rubber Packing" submitted by the Crane Co. Honorable mention was awarded four photographs in the professional group submitted by the following companies: Western Electric Co., Bausch & Lomb Optical Co., Battelle Memorial Institute, and Central Scientific Co.

In the Section on Photomicrography, first and third prizes went to Dr. J. E. Wilson, Bausch & Lomb Optical Co., the first prize being awarded for a colored photomicrograph. The second prize was awarded to L. L. Wyman, General Electric Co., chairman of the Society's Committee E-4, for his series of three prints.

It is planned that some of the photographs in the Exhibition will be reproduced in various issues of the BULLETIN, and accordingly, in the present issue are shown the first and second prize-winning prints in the General Section.



"Proportional Limit Test on Fully Threaded Stud."

Second prize winning photograph in the A.S.T.M. Photographic Competition, by W. F. Crawford, The Edward Valve & Manufacturing Co., Inc.

Recognition of Forty-Year Members

CONTINUING the practice inaugurated last year of recognizing members who had been affiliated with the Society continuously for 40 years, two individual members and two companies who have been members since 1899 were honored at the first session of the Forty-second Annual Meeting in Atlantic City. The two men who have been personal members were W. H. Broadhurst, Chemist, Bureau of Highways, Brooklyn, and F. G. Kennedy, Jr., President, Logan Iron and Steel Co., Philadelphia. The two companies were the Robert W. Hunt Co., which was represented at the meeting by its President, J. C. Ogden, who is also a personal member of the Society, and The Lowe Brothers Co., represented by E. W. Fasig, General Superintendent. The Robert W. Hunt Co. did not specify any Society representative until 1911 when Captain Robert W. Hunt's name was listed. Captain Hunt was president of A.S.T.M. from 1912 to 1913. At the present time F. M. Randlett, Vice-President and General Manager, is the official Society representative.

In 1899 when The Lowe Brothers Co. became members of the Society, they were represented by Houston Lowe, the Vice-President. Later Mr. John G. Lowe, Secretary, was the official representative, and since 1924 Mr. Fasig has served in this capacity.

The forty-year members were presented to Doctor Delbridge by Past-President Vassar, each of the men responding briefly as he was called. Doctor Delbridge presented the two personal members and the representatives with engrossed forty-year certificates.

Adding to the interest in this ceremony was the announcement by Mr. Ogden of the assumption by his company of a Sustaining Membership, further reference to this being made in another portion of this BULLETIN.

This brings the total of individuals and companies who have been affiliated continuously for forty years to 16, Albert Sauveur, one of the forty-year members recognized at the 1938 meeting, having died since that time.

Measuring Wear of Bearing Surfaces

INQUIRIES are received from time to time concerning the measurement of wear or abrasion. A recent note in the *Technical News Bulletin* of the National Bureau of Standards concerning this subject may be of interest.

"Some months ago a new method for measuring accurately the wear which takes place on bearing surfaces of machinery was developed at the Bureau. The method consists in making minute indentations in the wearing surface by means of a specially shaped diamond point. As material is worn from the surface, the dimensions of the marks change with the amount of material removed. Measurements of these impressions then indicate quickly and accurately the amount of wear that has taken place. The method is already being utilized in cooperation with other governmental agencies, and a private company has been licensed to build the equipment for general use."

The Significance of Tests

By Warren E. Emley[1] and L. B. Tuckerman[2]

MANY papers under this caption have appeared in A.S.T.M. publications. They have dealt with such items as the accuracy or precision of test data, the value of an average, and similar matters of great importance to the testing engineer. Fortunately such points are in general susceptible to treatment by mathematical formulas. Assuming that all such matters have been competently handled, so that we are reasonably sure of the correctness of the numerical results, within known limits, there still remains the broader question as to just what the results mean in terms of the value of the article tested.

The value of an article is related to its cost or price only incidentally, and sometimes quite indefinitely. Value is made up of three items: (1) the suitability of the article to perform the service expected of it in a satisfactory manner; (2) the durability of the article when used for that service; (3) such requirements as to appearance as the user may demand and be willing to pay for.

There seems to be a growing tendency to believe that testing methods are designed to measure the value of an article. This is not always the case. Many methods are used for "plant control," where the results of the test merely tell whether today's product is similar to or different from that made yesterday, but not whether today's product is better or worse than that made yesterday. A manufacturer of fabric who intends that his product shall have 64 threads per inch in the warp and a similar number in the filling will make routine tests of this product to make sure that his intentions are carried out. If he finds the thread count to vary from these numbers, beyond what he has set as a permissible tolerance, he knows that something has gone wrong with his manufacturing process. A thread count of 60 by 68 or of 68 by 60 may be a serious matter for him, because it indicates that his intentions have not been fulfilled. But neither he nor anyone else can say with assurance which of the three fabrics, 60 by 68, 64 by 64, or 68 by 60 is of the greatest value to the consumer.

Unfortunately, this kind of "stop-or-go" test is being needlessly used in some specifications for the acceptance or rejection of materials. A suitable test of this kind will, of course, assure the purchasing agent that each lot of the same material will be just like the previous lot. If the previous lot had proved satisfactory in service it protects him against receiving inferior material, but indiscriminately applied, it may also prevent him from getting anything better.

There are many tests, however, which have been developed to measure the value of an article, or some property related thereto. But even here, the results of the tests must be interpreted with discretion. One must always remember that value is measured by how well the article is adapted to the intended use, so that not only the nature of the article but also the nature of the intended use must be considered. It is generally true that an article which is quite valuable for one use is entirely worthless for another.

The relationship between the property measured and the value of the article may be quite definite and obvious, or it may be only general.

In the former case, the relationship between the property measured and the value of the article is sometimes so obvious that we are apt to lose sight of the true meaning of the test result. Take tensile strength for example. There are many cases where articles are designed to be used in tension, and a measurement of tensile strength therefore gives at least one criterion for estimating the value of the article.

The cohesion of particles, upon which tensile strength depends, is governed in large measure by the chemical composition and physical makeup of the material. But these factors are constantly subject to change, either designedly as by heat treatment of steel, or adventitiously as by change of temperature. Tensile strength may therefore be considered as being, in a sense, an inherent property of the material, but it must not be thought of as having an absolute definite value. This situation is further complicated by the necessity of using some machine for measuring tensile strength and thereby unavoidably introducing certain machine variables. The size and shape of the test specimen, the rate at which the load is applied, the amount of water which the material contains at the time of the test—these are a few of the variables which may have a marked effect on the tensile strength as measured.

So long as all of these factors are maintained constant, that is, so long as every operator tests the material in the same way, then the specimens will be arranged in their proper order. But if the testing method is varied in any particular, then the results may not be and in many cases are not comparable and misunderstandings and confusion are sure to arise.

Moreover, it is frequently quite unlikely that the conditions to which the article is exposed in service will be at all similar to the conditions under which it is tested. The tensile strength as measured in the laboratory may bear only a very general relationship to the tensile stress which the article will withstand in service. A manila rope which will withstand a tensile stress of 50,000 lb. when tested according to the standard procedure (conditioned to equilibrium with air at 65 per cent relative humidity at 70 F.; speed of testing machine 4 in. per min.; distance between jaws, 6 ft.) may withstand as little as 25,000 or as much as 100,000 lb. in actual service, depending upon the conditions. It may be soaking wet, or it may have lain in the sun for many hours. The load may come on with a sudden jerk, or it may come on slowly and remain for many hours. The distance between the fixed ends may be 2 ft. or 600 ft. It may run over sheaves and it may be knotted or ended in various ways.

It is frequently worth while to measure some property which is of no particular interest *per se*, in order to get a general idea of the quality of the article. Thus we measure the pH of leather, not because we have any particular interest in the acidity or alkalinity of the leather but because we have

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[1] Chief, Division of Fibrous and Organic Materials, National Bureau of Standards, Washington, D. C.

[2] Assistant Chief, Division of Mechanics and Sound, National Bureau of Standards, Washington, D. C.

proved by experiment that if the leather is much more acid than a pH value of 3, it is certain to deteriorate rapidly.

It is customary to specify that a cotton sheet having a given weight and thread count shall have a breaking strength of not less than 70 lb. per inch of width, not because 65 lb. would not be ample from the user's point of view but because we know that a strength much lower than 70 lb. is usually an indication that the cotton has been overbleached and consequently will soon wear out in service.

We might some time have learned from experience that if a certain kind of material has a high tensile strength it will also have a high degree of resistance to weathering. Tensile strength is easily measured, but, if the material is not to be subjected to tension in service, it would be of no direct interest; resistance to weathering is of direct interest, but is difficult to measure. We therefore would measure tensile strength, and using our experience to give us a method of conversion, interpret the results in terms of resistance to weathering.

The difficulty here lies in our innate tendency to extrapolate beyond proper limits. We are too apt to think that experience gained with one kind of material and two related properties, as illustrated above, will apply sufficiently well to similar materials or other properties. We may know that a phenolic plastic having a low water absorptive capacity will make a good electrical insulator, but that is no necessary reason for believing that an acetate plastic having a low water absorptive capacity would make a good electrical insulator and certainly no reason for believing that it will make a good powder-box.

When a test method has been adopted by the Society, this fact may be taken as *prima facie* evidence that an important group of experts in the field have decided that the test is good for something. Just what it is good for, is a matter which the user should carefully consider. Several of the standing committees of the Society have taken great pains in explaining just when the testing methods which they have developed should be used, and—more important—when they should not be. Each method will presumably measure a specific property of the article or material. Is the user interested directly or indirectly in this property? If so, does he have enough experience with the use of the particular material for the particular purpose to be able to interpret the test result in terms of service? Since no one but the user knows exactly what conditions the article or material will be subjected to in service, no one but he can answer these questions.

Tensile strength is easy to measure; there are standard test methods available, and most laboratories are equipped to make such tests. There seems therefore a growing tendency to measure the tensile strength of everything that comes to hand, and, what is still worse, to jump to the conclusion that the article having the higher strength is the better. (This statement applies equally well to properties other than tensile strength.)

Let us go back again to the definition of value. If we want to support a weight of 100 lb., obviously a rope which would not break under a load less than 101 lb. would, for a time at least, support the load. But, knowing the vagaries of rope, knowing that it breaks at lower loads when they are long continued, that its strength varies with changes in atmospheric humidity, that it may break under lower loads at its terminal fastenings, etc., we are willing to pay extra for some real assurance, and select a rope having a strength measured under standard conditions of 400 lb. If we are offered a 500-lb. rope at an increase of 10 per cent in the price, is it a better buy? If the 400-lb. rope will perform the service adequately at a lower cost, it should be of greater value to the purchaser. The 500-lb. rope will be the better buy only if its greater strength is accompanied by either greater durability or better appearance or both.

Building Code for California

THERE has just been issued a Building Code for California which was prepared for the California State Chamber of Commerce by committees representing California chapters of various organizations most concerned, including: American Institute of Architects, American Society of Civil Engineers, State Association of California Architects, General Contractors of San Francisco, and Associated General Contractors of America. Many other groups cooperated in the work. This new publication, it is stated, answers the need for a state-wide building code requiring adequate standards of building construction and reasonable resistance of such construction against earth movements.

In the code are incorporated a number of references to A.S.T.M. specifications and test methods. There appears in the code the following statement:

"(bl) *Reference to the American Society for Testing Materials.*

American Society for Testing Materials is the society whose specifications of methods for testing building materials, of taking samples for such tests, of the apparatus with which such tests shall be made, and of the standards of quality of the building materials to be tested, are most frequently referred to in this Code. . . ."

Copies of the code in special binding, 473 pages, can be obtained at $5 each from the California State Chamber of Commerce, San Francisco or Los Angeles.

Included in the code are A.S.T.M. specifications and tests covering the following:

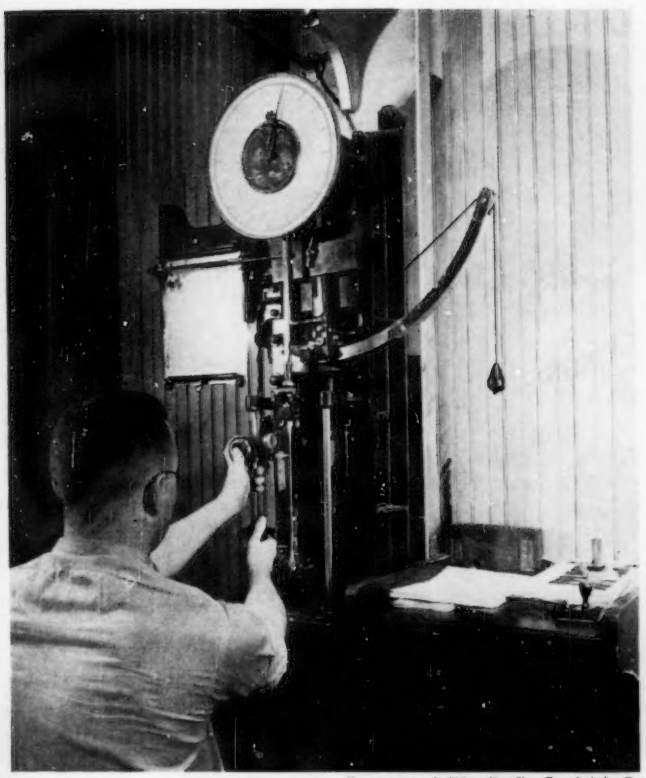
Steel for Bridges (A 7)
Billet-Steel Concrete Reinforcement Bars (A 15)
Carbon-Steel Castings for Miscellaneous Industrial Uses (A 27)
Gray-Iron Castings (A 48)
Welded and Seamless Steel Pipe (A 53)
Cold-Drawn Steel Wire for Concrete Reinforcement (A 82)
Quicklime for Structural Purposes (C 5)
Hydrated Lime for Structural Purposes (C 6)
Portland Cement (C 9)
High-Early-Strength Portland Cement (C 74)
Concrete Aggregates (C 33)
Making and Sorting Compression Test Specimens of Concrete in the Field (C 31)
Making Compression Tests of Concrete (C 39)
Sand for Use in Plaster (C 35)
Gypsum Plasters (C 28)
Building Brick (Made from Clay or Shale) (C 62)
Sand-Lime Building Brick (C 73)
Concrete Building Brick (C 55)
Structural Clay Load-Bearing Wall Tile (C 34)
Structural Clay Non-Load-Bearing Tile (C 56)
Load-Bearing Concrete Masonry Units (C 90)
Compression Testing of Natural Building Stone (C 98)
Gypsum Partition Tile or Block (C 52)

A. S. T. M. in the Rubber Industry[1]

By Arthur W. Carpenter[2]

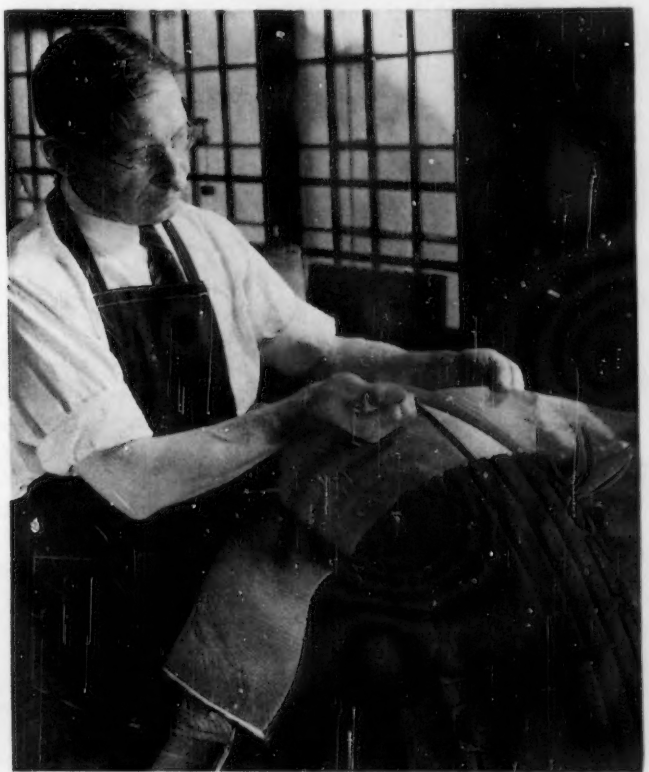
In discussing the service of the American Society for Testing Materials to the rubber industry, it is pertinent to consider both the objectives for which the Society is organized and some of the characteristics of the industry being served. Like many another manufacturing activity, not only is the producer of rubber products a supplier on a very large scale, but also a consumer using enormous quantities of other things such as crude rubber, chemicals, all sorts of cotton fabrics, wire, and metal parts. Many of these are products to those who supply them and likewise many rubber products are materials to those who use them. It would seem, then, that the word "materials" in the name of the Society should be interpreted in a very broad way.

While there may be differences of opinion as to what should be included under the heading of materials, unquestionably all would readily agree on the meaning of the word "testing" and its necessity, for by that means alone can we define the quality of materials or products, inform suppliers of our requirements and assure ourselves that we receive what we specify. Testing, therefore, is the important part of our name and reveals the prime function of our organization as stated in our charter as "the promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing."



Courtesy of The B. F. Goodrich Co.

Determining Tensile Strength and Ultimate Elongation of Rubber



Courtesy of The B. F. Goodrich Co.

The Tire Surgeon
Showing complex structure of modern heavy-duty truck tires.

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[1] Presented at a meeting sponsored by the A.S.T.M. Cleveland District Committee, Cleveland, Ohio, April 20, 1939.

[2] Manager of Testing Laboratories, The B. F. Goodrich Co., Akron, Ohio.

STANDARDIZATION

It seems obvious that acquisition of knowledge concerning the properties of materials and development and standardization of methods for determining those properties must precede actual preparation of specifications. Every specification assumes that the originator has specific knowledge of the essential characteristics of the article described and the significance of those characteristics either in relation to the service to be performed by the article or for control of uniformity of successive lots in the same service. The specification is the means whereby this knowledge is transmitted to others and must be so expressed that its requirements are mutually understood and capable of verification. To this end, the yardstick of duplicable standardized tests is a prerequisite of sound specifications. The preparation of specifications without proper preliminary work on test methods has often

Courtesy of The B. F. Goodrich Co.

Quarter Million Holes to Every Inch of Cushion

New cushioning material made of pure lastex has 250,000 openings to the cubic inch, permitting easy circulation of air and even cigarette smoke through mattresses, bus, automobile and furniture seats. Said to be cooler and lighter than any similar material so far produced.

been attempted under the exigencies of immediate needs. Instead of waiting on the orderly process of agreement and standardization, private specifications with hastily conceived, unproven tests have been promulgated. This has probably resulted in greater loss than would have been incurred by reasonable delay while standardization was vigorously prosecuted because argument and misunderstanding inevitably followed and the whole development of proper standards was retarded.

At the present time, standardization work in the various industries is in different stages of development. It appears in general, as would be expected, that the older industries have progressed further than the more recent ones. The properties and tests are well defined and many excellent specifications have been prepared by A.S.T.M. committees working in those fields. Rubber manufacturers have availed themselves extensively of these results and frequently utilize such specifications and methods of test in connection with their purchases of materials for use in their products such as textiles, metal parts, pigments and the like as well as for constructional materials of plant and equipment. However, the younger industries, like petroleum and rubber, have not yet reached this objective with their own products. Few standard specifications are available but much attention is being given to preparation of satisfactory test methods. Both of these industries have become commercially important only since the Civil War, and for a number of years thereafter their activities centered mainly in production and marketing expansion rather than in technical development. In the case of rubber, scientific testing has only been applied on any extensive basis since about 1904 and, even then, most of the test equipment was adapted from the metals field. One of the earliest tension testing machines designed especially for rubber was that of Schopper which became available in 1908. A.S.T.M. Committee D-11 on Rubber Products made its first report five years later, in 1913.

Rubber-Lined Acid Tank

60 ft. long, for continuous pickling of wide strip steel. Four of these tanks in series are used for each pickling unit. After installation, the inside of the tank is sheathed with 8 in. of acid-proof brick.

The upper-right insert shows the composite hard and soft rubber lining and expansion joint for the tank.

Courtesy of The B. F. Goodrich Co.

TESTS FOR RUBBER PRODUCTS

Much of the early work of the committee was concerned with writing of specifications under pressure from consumers. Most of these have had to be discarded, in some cases because they covered too narrow fields or in others because they failed to define adequately the desired properties or to provide satisfactory tests. The old records show conclusively the futility of trying to develop purchase specifications before laying the proper foundation. The time so spent has been largely lost, but that portion devoted to study and standardization of test methods proved to be the base for great progress in later work. Very often, argument and criticism of the old specifications led to cooperative investigation in different laboratories of the significance, accuracy, and reproducibility of various proposed tests. Usually, the tests were found defective, but the study pointed the way to improvement. Even such important tests as tensile strength, hardness, abrasion resistance and aging gave serious differences when performed on the same material in different laboratories. Clearly, something drastic had to be done, and about ten years ago Committee D-11 faced its problem squarely and decided to forget about specifications for the time being and to devote its energy intensively to the development and standardization of test methods and equipment. Since then, the whole picture has changed and the progress which has been made has been a great satisfaction to all who are familiar with the situation. Much remains to be done, but the accomplishment to date is indeed gratifying.

Let us now seek for a moment to ascertain, if we can, why the problem of testing rubber has so troubled a large group of competent technical men for so many years. The rubber technologist, who should know most about his products, has often been accused either of being stupid or of deliberately withholding vital engineering information from consumers because of trade secrecy, fear of competition, or some similar reason. I do not believe for a moment that either of these criticisms is valid. Surely, the technical man in the rubber industry is as well trained as his fellows in other lines. He came through the same schools and sometimes from other industries. One would need to be biased, indeed, to consider that there exists lack of brains or of engineering talent in an industry where a single large organization includes literally hundreds of technical graduates ranging from the youngster fresh from school to the former college professor with his degrees of Doctor of Science, Philosophy, or Engineering. On the other hand, how can such a group be accused of deliberately blocking progress in an industry which has increased the service life of its principal product nearly tenfold and at the same time reduced the cost to the consumer by at least two-thirds. I think we must look elsewhere for the real difficulty.

COMPARISON OF RUBBER AND METALS

Suppose then, we examine the nature of the test problem for rubber and compare it with that for metals which may be more familiar to many. In the first place, the name "rubber" is a general term, like the word "metal" and may refer to a large variety of materials having widely different characteristics. Although these have not been formally subdivided into smaller classes to the same extent as metals, distinction is made between crude rubber and the familiar compounded, vulcanized product. Further general classifications recognize major differences, depending on physical condition and degree of vulcanization. Thus, we have the rigid hard rubbers, like ebonite, porous forms known as sponge rubbers, liquid rubbers in cements and dispersions, and finally the flexible soft vulcanized rubbers which are those usually thought of when one says "rubber." Each of these embraces a large number of different compositions with an extensive range of physical properties. One major company alone produces currently more than 1200 kinds of rubber compositions in order to meet differing requirements. In variety, therefore, rubber may be compared to the entire metals field which includes both ferrous and non-ferrous compositions divided further into numerous irons, steels, brasses, bronzes and alloys of many other metals. Although these metals, too, have widely different physical and chemical properties, they are all relatively rigid in the ordinary sense. Rubber, on the other hand, if we exclude the hard and the liquid varieties, has for its outstanding characteristic, flexibility or ease of deformation and ability when deformed to store up energy which is to a high degree returned upon release from the deforming forces. Furthermore, while metals are relatively stable and retain their properties with reasonable permanence when once established, rubber having as its base an organic vegetable material is not only subject to quite rapid perishing unless properly protected but also changes in physical properties both with age and often under repeated action of impressed forces. These two characteristics of rubber—large deformation under impressed force and easy alteration of physical properties during handling—are, in my opinion, responsible for most of the standardization difficulties which have been encountered with this material.

The extreme deformability of ordinary vulcanized rubber compounds introduces many complications into test procedures. For example, measurement of thickness becomes difficult because contact pressures must be carefully controlled to avoid change of dimensions during the actual observation. Hardness tests by indentation methods cannot be made by ordinary means because the range of possible travel with different compounds is so great that the scope of any standard equipment is exceeded. Tests for resistance to abrasion are confused by the fact that the rubber tends to flow away from impressed forces, in consequence of which hardness and modulus of stiffness become unusually important variables. The situation is even worse when the abrasive forces are associated with impact. Even the determination of tensile strength gives misleading results because the total stress can only be referred to the original cross-section of the specimens as is usual with metals. In the latter case, the sectional area does not change substantially until just as failure occurs, while with rubber the change is progressive during the whole loading operation and the section is reduced enormously. As a result, a reported tensile strength of rubber of 5000 lb. per sq. in. of original cross-section may be equivalent to an actual tensile strength computed on the section at failure as high as 30,000 lb. per sq. in.

It may be interesting for a moment to compare the form of the stress-strain curve for a typical rubber with that of steel (see Fig. 1). Thereby, also, we shall find the reason why some design data which engineers require is not tabulated in handbooks for rubber as for steel.

Inspection immediately reveals that rubber does not follow Hooke's law of the proportionality of stress to strain as

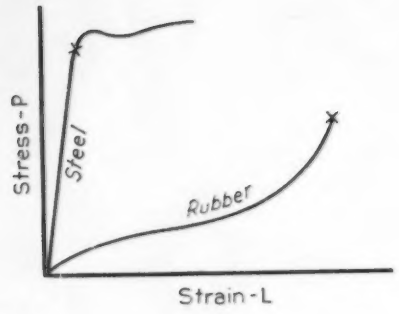

Fig. 1.

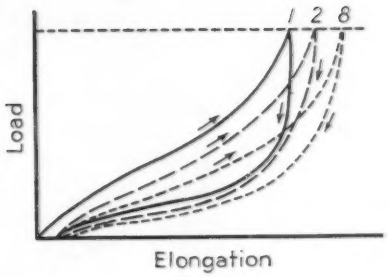

Fig. 2.

does steel below the elastic limit, since no part of the rubber curve is a straight line. Then, too, rubber shows no yield point and only at the breaking stress can the material be said to have what we may call an elastic limit. Also, the rising curve of rubber indicates the stiffening effect of increased stress, which can be felt when one stretches a rubber band and which is utilized to advantage in design for limiting deflection in shock absorbers and for giving hardness combined with resilience in golf balls. Engineering design of structures usually requires use of the modulus of elasticity of the constructional material in computations. For steel, this modulus is the slope of the stress-strain curve below the elastic limit and numerically equals the stress which would if possible double the length of a segment having unit dimensions. The familiar formula $E = \frac{P}{L}$ used for steel is only a special form, when Hooke's law holds, of a more general formula applicable with all materials, $E = \frac{dP}{dL} \cdot \frac{l}{a}$ where P equals load, L elongation, and l and a are original dimensions. It is evident then that the value of the modulus of elasticity of rubber varies, depending upon where on the curve it is taken. Also, each kind of rubber compound has a different curve, so the number of possible moduli is legion and impossible to tabulate.

Reference has been made to the changes in physical properties of rubber that occur in repeated deformation and in aging. The latter are so familiar as to require no elaboration. Everyone has observed the hardening and loss of strength and of elasticity that rubber bands, inner tubes, and other rubber products undergo when exposed to the oxygen of the air for extended periods. It is also well known that the deterioration is more rapid as temperature is elevated. It is desired here to mention only that chemical antioxidants have been developed in the past fifteen years which may be incorporated in the rubber, greatly retarding this age deterioration and prolonging many-fold the useful life of numerous rubber articles. The changes due to repeated deformation are not so well understood nor so readily modified, although some progress has been made in recent years. Some idea of the effect of repeated stressing may be had from the stress-strain curves of Fig. 2 showing successive cycles of extension and retraction. For brevity only the first, second, and eighth cycles are given. It is noted that each cycle follows a different path, although the loops become smaller in successive cycles and their course tends to become fixed. Since the area under each curve represents the work done in extension or returned in retraction, the differences corresponding to the areas in the loops must be the energy lost during the cycles. This hysteresis loss is dissipated as heat which, unless disposed of by radiation or conduction, raises the temperature changing further the properties of the rubber and hastening its deterioration.

Another factor complicating the development of test standards for rubber products is the structural complexity of some of these articles which renders analysis of stress distribution during both service and test extremely difficult or even imposible. In design of steel structures, stresses and shapes are usually regular and geometrical, involving relatively simple mathematics and standardized methods of analysis so that tests can be made at least to approach actual service conditions. Let us consider for a moment the automobile tire. Its shape is that of a modified torus and the cord reinforcement which withstands the stresses consists of many strands extending angularly criss-cross of the carcass from one bead to the other. No one has yet been able to figure out completely the mathematics of this situation, though it has been worked on for years. The flexible reinforcing structure is buried in a matrix of different rubber compositions found by trial and experience as well as by test to be most suitable for the service each must undergo. Then, too, what is the service? Quite obviously, rolling along on many different vehicles in widely separated parts of the country under innumerable road conditions, no two tires ever experience through their whole lives exactly the same service conditions. The test problem would be simplified if average service could be defined or if some other reference standard of service for evaluation purposes could be agreed upon.

ACCOMPLISHMENTS

Enough has surely been said concerning the difficulties of the standardization problems which have confronted Committee D-11 on Rubber Products in its effort to serve industry. Perhaps it is now more evident why progress has not been as rapid as many people desired. There remains, in conclusion, only the more pleasant task of summarizing briefly what has been accomplished in spite of these difficulties. The committee has sponsored some 16 approved methods of test covering most of the usual procedures for evaluating physical and chemical properties of soft vulcanized rubber. These include methods for chemical analysis as well as for tension testing, aging, adhesion, hardness, abrasive wear, flexing, compression set and behavior in liquids. Also, meth-

ods are recommended for certain products such as rubber insulated wire and cable, rubber hose and belting, and the committee is actively working on suitable tests for hard rubber[3] and sponge rubber.

In addition, numerous material specifications are now available. Four of these are for different kinds of insulated wire and cable and the others cover such products as fire hose, electrical tape, electricians' gloves, and switchboard matting. The special pamphlet of more than 200 pages which has been issued by the Society, containing all of the rubber standards has received wide acceptance for use as a laboratory test manual on rubber. The committee, which consists of 89 members—37 being producers, 28 consumers, and 24 general interests—cooperates in its standardization work with the Crude Rubber and Testing Committees of the American Chemical Society, the Technical Committee of the Rubber Manufacturers Association, the appropriate sections of the Association of American Railroads, the National Electrical Manufacturers Association, the Fire Protection Group and others interested in the rubber field generally or as consumers and producers. At present, a project is actively under way jointly with the Society of Automotive Engineers on the organization of a special technical committee to concentrate on the development of standards for automotive rubber products excepting tires and tubes. During recent years rapid strides have been made and great interest is now apparent in the work of Committee D-11. It is not unreasonable to anticipate that future progress will be even more satisfactory.

[3] New Tentative Methods of Testing Hard Rubber Products were accepted by the Society on June 28. They cover chemical, physical and electrical tests.

A New Method for Measuring Placeability of Concrete

By G. W. Hutchinson[1]

AMONG the several problems encountered in the design of concrete for the Claytor Dam was one which necessitated a means for comparison of various mixtures as regards their relative placeability. In describing the method worked out at the Claytor Hydro Project laboratory for this purpose, it was at first thought to use the term "workability" rather than "placeability." "Workability" was discarded as investigation indicated that equal measurement could be secured with a concrete of poor design requiring excess water, as judged by bleeding or other indications of free water after the concrete was tested, and a truly plastic mix containing no excess water. The term "workability" also would appear to invite criticism which would involve theoretical discussion, whereas the term "placeability" lent itself more as a description of the mechanical means employed to obtain results. The water-cement ratio theory is the basis of design in the use of this method for determining placeability. The desire was to design a plastic mix with a low water-cement ratio and to get the concrete properly into place by internal vibration.

Present means of measurement may warrant practical application where the richer or wetter mixtures are used. Unfortunately, when low cement contents are used, as in mass concrete for dam construction, neither the slump test nor the flow table are applicable. Further, where a project, such as the Claytor Dam, is of sufficient magnitude to warrant close control and a greater degree of refinement in the proportioning of materials, closer operating limits are justified. Low cement content and reduced water ratio exaggerate the small differences normally discernible in the richer and wetter mixtures.

While the economy of placing concrete by internal vibration has been universally recognized, this method is absolutely necessary to obtain economy in the leaner mixtures of lower relative water-cement ratio. The placeability machine was designed with the idea of providing a measure and comparison of different concrete mixtures using vibratory action. It was found, as would be expected, that it allowed exploration into the field of mixtures which has not been possible by other methods. Investigation indicated new ideas as to the behavior of plastic and semi-plastic as well as the exceedingly dry concrete mixtures. Proof was also indicated of many contentions regarding concrete design which have been accepted in the past but lacked means of substantiation.

The device, Fig. 1, consists of a model 2 Viber having its lower end, or point of greatest vibration, clamped rigidly to a hopper which is in turn connected to a base plate. Mounted on top of the hopper, by means of bolted webs, is a cylinder provided with a sliding gate at the bottom. A plunger is provided which slides freely within the cylinder and is equipped with a handle wider than the diameter of the cylinder. The test consists of mixing a batch of concrete (340 cu. in.) of exact proportions by absolute volume and placing it in the cylinder with the gate closed. The gate is then pulled and a certain amount of the concrete drops into the lower hopper. When placed in the cylinder, the plunger comes to rest on the top of the concrete. The vibrator and stop watch are started simultaneously and the time, in seconds, is measured for the period required for the plunger to travel downward until this action is restricted by the contact of the handle with the top of the cylinder. The handle of the plunger comes to rest on the top of the cylinder at the time the concrete has been properly compacted in the lower hopper. The plate attached to the lower part of the plunger shaft rests on the surface of the concrete which has been leveled off during the vibration period.

Figures 2 and 3 indicate typical results secured in measuring placeability. Figure 2 provides data in connection with several fine aggregates being compared. The water and coarse aggregate gradation were constant. In certain of these mixtures, there is a clearly defined optimum fine aggregate content, whereas in others, quite a variation can occur without affecting the placeability with the given water ratio. In general, it indicates that higher fine aggregate contents than

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[1] Concrete Technician, Claytor Hydro Project, Appalachian Electric Power Co., Dublin, Va.

are normally now considered can probably be economically used. Economy would dictate recognition of this fact on account of the difference in cost between fine and coarse aggregate under general market conditions.

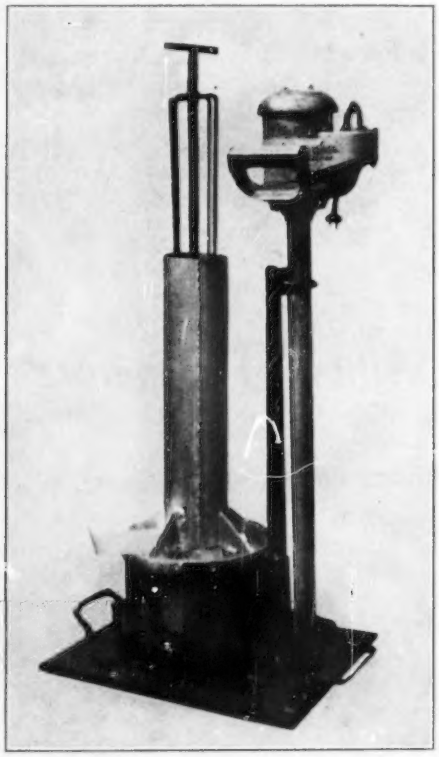

FIG. 1.—Method of Measuring Placeability of Concrete.

The appearance of the concrete after test furnishes indications as regards the design of concrete to correct for bleeding, water gain, etc. If the term "excess water" can be construed as that water necessarily added to get the concrete in place but impossible of being held as an integral part of the mass, the method would determine the comparative extent to which excess water is necessary for any mixture. It will be noted that the certain lower and higher fine aggregate contents have the same placeability measurement. The mixtures containing fine aggregate contents lower than the optimum indicate their faults by the appearance of excess water on the surface after the test. Those containing the higher relative fine aggregate contents have become sluggish due to increased surface area of the total aggregate with the given water content.

Figure 3 indicates a relation between fineness modulus and placeability where all mixtures were compared with a constant water-cement ratio. These data consider mixtures provided to give the various fineness moduli in the orthodox manner and not by the more accurate basis of design as might be indicated for different gradations of coarse aggregate by the method outlined in Fig. 2. The results given are typical to describe the method rather than to indicate design.

The speed and amplitude of the vibrator, in general, determine the range of mixtures that can be used in the test. In

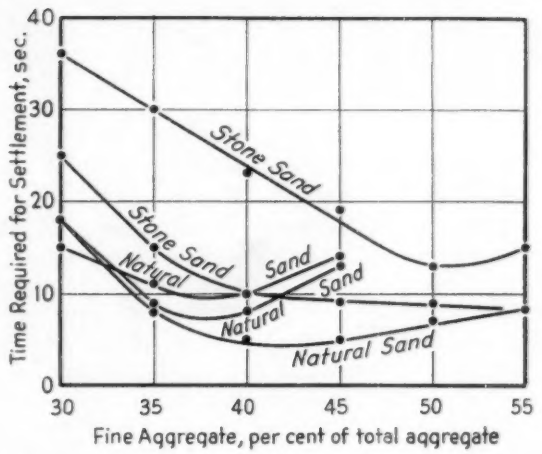

FIG. 2.—Typical Results in Measuring Placeability.

the apparatus shown, the original speed was 7000 r.p.m., but later developments have increased this speed to 8000 r.p.m. Lower speeds do not appear to compact the concrete as well, regardless of amplitude, whereas the higher speeds, with unbalanced amplitude, tend to "fluff" the drier mixtures in the lower hopper and cause the range of application to be automatically restricted. The device provides, at the end of the test, a thoroughly compacted mass using mixtures which range from those such as are used in dry tamp products manufacture to as wet as would normally be designated as having up to a 3 to 4-in. slump.

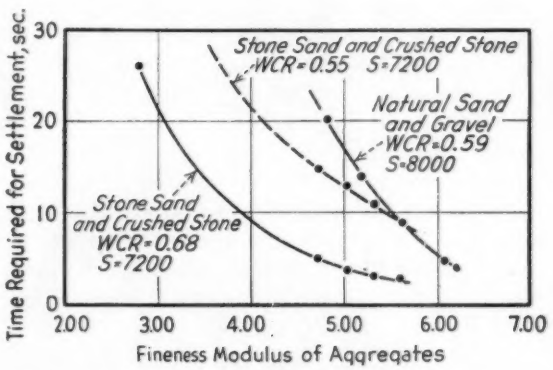

FIG. 3.—Typical Results in Measuring Placeability.

WCR = Water-cement ratio by weight.

S = Speed of Vibration.

This means of comparison, or evaluating various concrete mixtures, includes two of the three physical properties of commercial aggregate—particle shape and gradation—so that the third—structural soundness—may constitute the only determination necessary by compression testing, freezing and thawing, or other means of physical testing, etc. By applying the method in the study of the characteristics of various materials, a means is provided to determine correction, for instance, either in gradation or particle shape of aggregate, in order to enhance its value as a concrete ingredient. It appears to show promise as a method through which most of the physical properties of concrete materials may be evaluated if the water-cement ratio is to be used as the basis of design.

Methods of Industrial Hygiene Procedure and Testing[1]

By G. C. Harrold[2]

In industrial hygiene work, whether it be air analysis or analysis of toxic substances, the collection of the sample is probably the most important laboratory phase. This is, however, not nearly as well standardized as many other divisions of the work. Certain preliminary precautions aid in the accurate taking of the sample in connection with air analysis. To obtain correct evaluation of any given situation where important decisions are to be made, a number of investigators are making use of the smoke bomb to determine the direction of air currents. Titanium tetrachloride is one well recognized agent though care must be exercised as the substance is corrosive to metals.

The thermometer-anemometer and velometer are also used to determine velocities and directions. The thermometer-

FIG. 1.—Thermometer-Anemometer.

anemometer (Fig. 1) is one of the most recent developments in the air velocity field. The value lies in the accurate results obtainable in the range from still air to 200 linear feet per minute, where the velometer becomes useful.

Once the direction or directions of air flow are determined, the samples can be taken with some degree of certainty that the worst and best situations are known, as well as some idea as to the average condition. However, it is now well recognized that merely taking one sample on any one day will not give a true picture of conditions as they exist in the area being investigated.

Due to the numerous variables, this situation demands numerous tests representative of the conditions at any one time and the duplication of these tests over a period of several days. Such days should be chosen as to give a true sample of all variations that usually occur. This is particularly true of gases but applies in great measure to dusts, fumes, and mists also, as the size range of the substances investigated by the industrial hygienist is such as to be air borne for long periods of time and hence affected in much the same way as gases.

We have found as high as 500 per cent variation from one day to another in the same test spot with the same operation taking place. It is not uncommon to have variations of 200 and 300 per cent. Obviously, statements made or ventilation installed on the basis of any one day's test would be more harmful than if no tests at all were made. However, if we choose four or five different days, and in a few cases only three different days, we can arrive at a reasonable working average. Among the factors to be considered in getting an average result are the external atmospheric conditions and the time of day during which the test is taken.

One day should be a typical clear, cool day with high barometer and low humidity. Another should have relatively high humidity with little or no air movement. Others should be selected for high humidity and rapid air movement. The direction of the wind should be considered on any one day in relation to the direction of air current normally prevailing near the operations concerned.

Whether samples are all taken at 8 a.m. or all at 10 a.m. would seem of little moment but, due to irregularities in production and possible building up of toxic concentrations during the work period, this is a factor to be considered. This is particularly true of tests that are being made for the first time or those which are made infrequently. We have found that best results are obtained when air sampling is conducted over four parts of the working day, two in the morning and two in the afternoon. On a three-shift job, one test on each of the other shifts should supplement the information previously obtained. Actually, what we have described is not standard practice but represents what should be done to show a good result. Unless special conditions arise, we have found that one can eliminate all the tests on the second and third shifts and one of the afternoon tests. It should be noted that these tests at different times of the day are conducted as a part of the four or five tests with variable atmospheric conditions. They do not add to the total sampling and testing load.

In addition to the question of how many tests should be conducted, we should consider what kind of samples to take. While not standardized, it is becoming accepted that both spot samples or grab tests and prolonged continuous samples collected over a period of 15 min. to 2 hr. should be had. In some situations, after the first survey when conditions are tested and studied very thoroughly, it should be sufficient to follow up with routine grab samples. At least once a year this should be supplemented, however, with samples taken over a long period of time.

AIR ANALYSIS

This situation can best be illustrated by an examination of what should be done in the case of dusts. As an example,

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[1] Presented at a meeting sponsored by the A.S.T.M. Detroit District Committee, as part of a Symposium on Industrial Applications of New Testing Methods, Detroit, Mich., April 19, 1939.

[2] Industrial Hygiene Laboratories, Chrysler Corp., Detroit, Mich.

let us take silica dust which is one of the most important from a hygienic point of view. In an initial study, until the general situation has been thoroughly clarified, all samples should be taken by either of two methods. The standard method in the United States has been the use of an accurate air sampler, either air, steam or electrically driven, in conjunction with the Greenburg-Smith impinger. The sample is taken during a period of time of from 2 to 20 min., and then the samples of dust dispersed in a liquid phase are taken to the laboratory for counting.

This method will collect substantially all the particles of from 0.5 μ up, which is the range of size that is significant. However, it is difficult to collect the sample in such form as to be useful for petrographic analysis and chemical analysis. To meet this and other objections, the electrical precipitator was devised and is now available commercially. This instrument will collect 100 per cent of practically all dusts down to 0.1 μ which is a size range usually called fume or smoke. The sample is dry and hence can be used for petrographic as well as chemical analysis. By washing into a suitable liquid, the dust particles can be counted with assurance that the particles have not been broken up by impingement.

Both of these methods give samples which are taken over a more or less long period of time. However, after conditions in the dusty area have been studied thoroughly and suitable corrections can be made, it becomes possible to shorten the procedure considerably. For control purposes, as a part of a progam to see that conditions remain as good as possible, we can use grab samples which can be taken in a few seconds and counted in much less time than is needed with wet counting cell technique.

Such instruments as the konimeter and the Bausch & Lomb Konoscope are examples of grab sample collectors. In these instruments, a microscope is included in the instrument so that the samples, usually about thirty in number, can be read in any convenient darkened room. It should be emphasized that resort should not be made to such shortened methods until the real conditions are known, as the short methods give comparative results only.

Lead fumes or welding fumes should be collected with the electrical precipitator as other collecting methods are not efficient when particles of this size range are encountered.

Mists and vapors can be collected very well with an air lift vaporizer which is essentially a method of impinging and wetting the liquid particles entrained in a given volume of air.

Gases are usually collected with absorption trains at a rate of around 1 liter per minute as opposed to the relatively high rates previously discussed of 1 cu. ft. or more per minute.

Several special direct-reading instruments and methods are available for testing suspected areas for some gases or vapors. Thus, we have equipment for detecting carbon monoxide, hydrogen sulfide, and hydrogen cyanide. The combustible gas indicator has been made more sensitive to give readings in the toxic range. This instrument has particular value in obtaining readings on atmospheres contaminated with paint solvents. The same principles, with adaptations, that are used in the combustible gas indicator are used in the benzol indicator. Several other instruments permit the quick determinations of air-borne contaminants through indirect determinations. We have an instrument for evaluating the amount of chlorinated material in the air through the combustion of the chlorinated substance and the subsequent determination of the halogen. The interferometer can be used to determine some vapors through the change in the refractivity of the contaminated air. These are not specific methods, however, and require intelligent evaluation of the results obtained.

Aside from the direct reading instruments, the usual procedure is to take collected samples to the laboratory for analysis. As mentioned previously, dusts containing silica or asbestos are counted. Such toxic substances as lead, chromium, cadmium, selenium, mercury, zinc, etc., are analyzed chemically. Due to the small quantities available, micro methods have to be used in the case of many of the substances encountered. While we have previously discussed only air contamination, the statement with respect to microanalysis applies with equal force to the determination of the small quantity of $ZnCl_2$ or chromium in a glove in cases where a dermatosis is involved.

Lead is commonly determined by a modified chromate or by a dithizone method. When larger quantities of lead are found, the chromate method is satisfactory. Briefly, the lead is freed from interferences and precipitated as the insoluble basic lead chromate through addition of excess $K_2Cr_2O_7$. The final determination may be made colorimetrically through the use of diphenyl carbazide. This reagent gives good results in determining the excess hexavalent chromium ion.

More satisfactory for smaller quantities of lead is the dithizone method. A modification which we have worked out for air analysis permits the determination of many more samples because less sampling time per sample is needed and greater speed in analysis results. While this method is ideal for air or biological analysis and details have been so worked out that any chemist should be able to get accurate results, it should be emphasized that extreme cleanliness is absolutely essential due to the extreme sensitivity of the diphenyl thiocarbazone reagent. A large amount of recent research work supports all the claims made for the method but clearly points out the need for expert technique in analysis, if false conclusions are to be avoided. The only interferences are bismuth, tin, and thallium, and these may be removed.

Chromium is an important material when in the hexavalent state. One research successfully used an iodometric titration method. Many investigators are using a modified colorimetric method using *s*-diphenyl carbazide as the indicator and, under most conditions, this method will give accurate selective results. Using a strong hydrochloric or acetic acid solution, as little as 1 p.p.m. may be detected. Interference by zinc, cobalt, lead, nickel and silver have to be guarded against.

Mercury in the form of vapor can be detected by the General Electric selenium sulfide detector. Rapid direct determination by the blackening of a selenium sulfide test paper indicates as little as 1 part mercury vapor per 4 million parts of air. The electrolytic method of Frazer has also been used but is cumbersome and long.

Cadmium is usually determined by determining the sulfide nephelometrically using ultraviolet light against standards prepared at the same time. A dithizone method gives good results but zinc must be guarded against.

REPORTING OF RESULTS

Once the amount of contaminant is determined through either chemical or physical methods, the results are reported in one of several ways. Thus, some dusts such as silica, silicates, or asbestos are usually reported as so many particles of a certain size, dark or light field count, per cubic foot of air. This type of reporting is used since only particles of less than 12 or 15 μ could get into the lung to cause harm. Some toxic dusts such as lead, chromium, cadmium, manganese, zinc, etc., are reported on a weight per volume basis. This is usually in units of milligrams per cubic meter or milligrams per ten cubic meters of air. The figure, 10 cu.m., is used as it represents in a rough way the amount of air a workman will breathe during a working day.

Such substances as carbon monoxide, hydrogen sulfide, or hydrogen chloride may be reported on a percentage basis, which is essentially volume of contaminant per unit of volume. These substances and others are also reported as parts of contaminant per million parts of air which is another way of saying the same thing as is said when percentage is used. Thus, 0.01 per cent carbon monoxide is essentially the same thing as 100 p.p.m.

While all these methods of stating results have some merit, it should be noted that errors can easily arise due to the use of a different basis for two substances. Due to the differing molecular weights, what appears to be an identity when reported as parts per million is actually not so. Thus, a value of 100 p.p.m. is set as a maximum allowable limit for prolonged exposure to both carbon monoxide and carbon tetrachloride. Assuming the carbon tetrachloride to be in the gaseous state, which is not always true, we have under the conditions mentioned an actual amount by weight of about one-fifth as much carbon monoxide as carbon tetrachloride. Such apparent inconsistencies must be kept in mind when considering some of the results obtained.

Reference standards, of course, must be set up so that some amount of a potentially irritant or toxic substance which will not cause deleterious effects over reasonably long periods of time can be referred to in the course of the investigation. There are several sources of these threshold values. It is apparent that such values do not mean that larger exposures are not safe for short periods of time. A few of the more generally accepted values for prolonged exposures are listed below:

Benzol	50 to 100 p.p.m.
Carbon monoxide	100 p.p.m.
Carbon tetrachloride	100 p.p.m.
Hydrogen cyanide	20 p.p.m.
Hydrogen sulfide	20 p.p.m.
Hydrochloric acid	10 p.p.m.
Chromic acid	1.0 mg. per 10 cu.m.
Lead	1.5 mg. per 10 cu.m.
Mercury	1.0 to 2.0 mg. per 10 cu.m.
Zinc oxide fume	150.0 mg. per 10 cu.m.

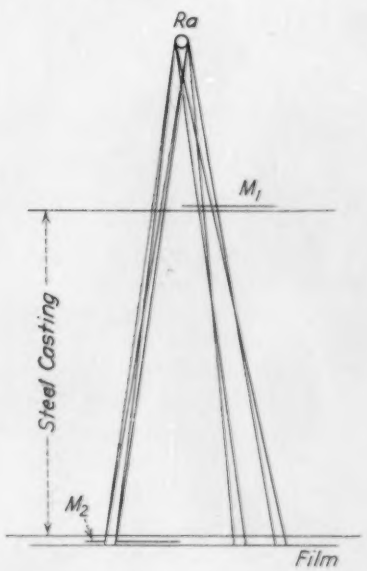
The fact is that each situation has to be evaluated as a separate problem, and the application of given values determined by the conditions of work, surroundings, time of exposure, and the prevalence of possible ameliorating factors. It may well be appreciated why so much of this short discussion is devoted to the collection of the sample. The conditions surrounding the taking of the sample have so much to do with the evaluation of the results obtained that no correct interpretations can be made until such conditions are all established.

While this résumé is admittedly very incomplete, we have attempted to give some idea of the general testing procedures employed in industrial hygiene work with emphasis on some factors which are not standardized. Nevertheless, they are fundamental to the general testing procedures which have a vital bearing on the interpretation of results.

Discussion of Paper on "Precision Radiography"[1]

Mr. H. R. ISENBURGER[2] *(by letter)*.—With reference to the paper by G. E. Doan on "Precision Radiography," appearing in the March issue of the ASTM BULLETIN, I would call attention to a statement made by Hugh W. Hiemke, Bureau of Engineering, U. S. Navy, appearing on page 772 of the 1938 Welding Handbook, A.W.S., that "the gamma-ray method is most advantageously applied to unequal and very thick sections, while the X-ray method is best adapted to uniform and thin sections. Up to thicknesses of 2 in. the X-ray method is more sensitive, and requires much less time." Since most of the welded seams to be radiographed are less than 2 in. thick, we contend that the method suggested by Mr. Doan has no particular use. The results on all welded joints, whether done by us or others, whether in this country or abroad, show that radium cannot be used to detect the fine defects which we have to show up if this inspection is at all worthwhile.

But even if it were not for this reason, the practical application is obviously impossible. There are two extreme sections



[1] Paper published in ASTM BULLETIN, No. 97, March, 1939.
[2] President, St. John X-ray Service, Inc., Long Island City, N. Y.

to each object under investigation: the surface toward the source of radiation and the surface toward the film. We want to find defects which are located in between these two surfaces, that is, defects may lie close to either one of these sections. If we place the source of our radiation in the most advantageous position for a defect located close to the surface nearest the film, defects located throughout the material and particularly those toward the surface nearest the source of radiation are at a disadvantage, and *vice versa* if we expose for defects close to the source of radiation.

The greater the thickness to be radiographed, the worse this condition gets. The writer has recently examined cast steel 9½ in. thick. We used 500 mg. of radium at 15-in. focus to film distance. The area covered by this exposure was about 10 in. in diameter. Two penetrameters M and M_2, $\frac{3}{16}$ in. thick each, having a $\frac{5}{16}$-in. hole drilled through one end, were placed on each surface respectively as indicated in the accompanying figure.

Only the penetrameter nearest the film showed up in the gammagraph. One look at the sketch explains the obvious reason for this. And since these conditions prevail in practically all our problems where radium is employed, we cannot see the value of geometrical analysis of the conditions in gamma-ray testing as suggested by Mr. Doan.

[3] Professor of Physical Metallurgy, Lehigh University, Bethlehem, Pa.

MR. GILBERT E. DOAN[3] *(author's closure, by letter).*—Mr. Isenburger does not see the possibility of using the equation because the flaw may lie at an unknown level below the surface of the specimen. If the flaw is always assumed to be in the most unfavorable position for detection, namely at the surface *farthest* from the film, as was done in the derivation of the equation, then the setting calculated from the equation will insure registry of flaws in all of the more favorable locations, that is anywhere nearer to the film. These are the conditions under which our experiments were carried out.

It would appear from Mr. Isenburger's quotation that he would like to see the use of gamma rays restricted to as narrow a field as possible. We are not interested in this restriction, nor, on the other hand, do we wish to see the extension of gamma rays to purposes better served by X-rays. The sole purpose of the paper is to bring greater precision and lower cost into the use of both types of radiation.

A Laboratory Concrete Mixer

By H. R. Webb[1] and W. W. Preston[1]

A SMALL concrete mixer was recently built by the Civil Engineering Department, University of Alberta, for use in the concrete laboratory. As the authors found very little information available on small mixers the following points may prove of interest to concrete laboratories.

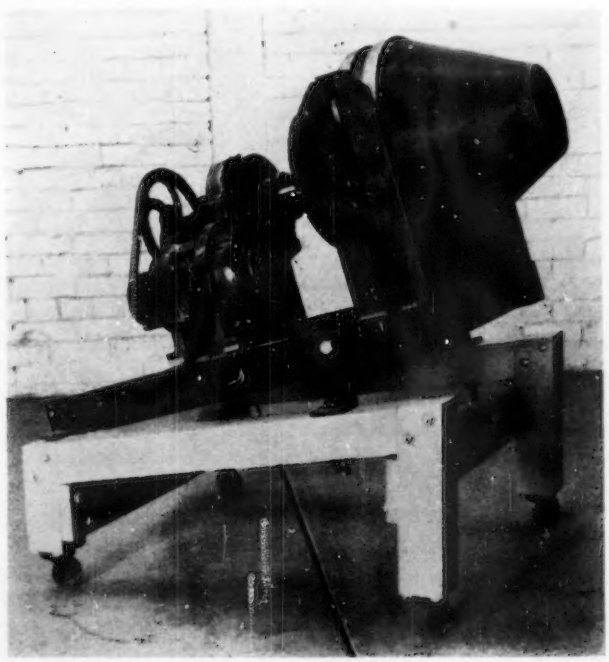
Mixers available on the construction equipment market were all of too great capacity, as the usual batch in this laboratory is just enough for two 6 by 12-in. cylinders. This seemed a very small amount so the mixer capacity was selected as two-thirds of a cubic foot, or roughly, the amount for three 6 by 12-in. cylinders or 100 lb.

One of the authors had observed the operation of the mixers at Grand Coulee Dam, and had examined the model in the testing laboratory there. Those mixers had been subjected to exhaustive testing before the final dimensions and blade arrangement were adopted, so a small model of them seemed to offer a quick solution to the problem of design of the drum. The office of F. A. Banks, Chief Engineer at Grand Coulee, very kindly supplied dimensions of the drum and blades. The large mixers have a capacity of 4 cu. yd., or 108 cu. ft., so the linear scale ratio was found to be the cube root of 108/0.67 or 5.451. A gear reduction box of 30:1 ratio from an old washing machine was purchased, and this, with a 2½ times reduction from motor to gear box, provides the desired mixer speed.

A steel angle frame for supporting the various parts was designed, detailed and fabricated locally. Figure 1 shows the assembly as completed. Dumping is done by lifting the base frame at the back end, the whole rotating about a pivot below and between the drum and motor.

The assembly is mounted on a 4 by 4-in. timber frame with casters, making it easily moved and adaptable.

So far, no studies have been made of the efficiency with which mixing is accomplished in this little machine but observation seems to indicate thorough and complete blending of all ingredients in the mix. During February, 1939, about 200 cylinders and a 10-ft. beam 8 by 13 in. in cross-section were poured, the mixer fully reaching all expectations.



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Industrial X-ray Protection[1]

By Lauriston S. Taylor[2]

PROTECTION against undesired exposure to X-rays or the gamma rays from radium can be had, but for economy and convenience it is desirable to analyze closely, with certain fundamental principles in view, each particular problem. Basic rules for X-ray and radium protection have been promulgated by the International Commission on X-ray and Radium Protection and published in numerous journals. More detailed rules, prepared in this country, are available in *N.B.S. Handbook 20* (X-ray Protection)[3] and *N.B.S. Handbook 23* (Radium Protection) (*1*)[4]. Reference to these is recommended before planning a new X-ray installation.

The handbook on X-ray protection gives the rules for maximum protection; if followed strictly, any errors will be on the safe side. In the present discussion, certain qualifications are given which may permit a more economical disposition of protective barriers and devices. At the same time a number of miscellaneous points requiring special emphasis are considered.

TOLERANCE DOSE

The so-called "tolerance dose" is the total X-ray energy that a person may receive continuously without suffering any damage to the blood or reproductive organs. This is expressed best in roentgens or in terms of an erythema dose.

The tolerance dose recommended by the International Protection Commission is taken as a 7-hr. daily exposure at a dosage rate not exceeding 10^{-5} roentgens per second (*2*). This is roughly 10^4 times the dosage rate of cosmic radiation. It is argued by the genetecists that this is 10 times the safe dosage; or, in other words, the tolerance dosage rate should not exceed 10^{-6} roentgens per second. Their figure is based on the elimination of any second generation genetic effects, whereas the accepted figure of 10^{-5} roentgens per second is based on the effect upon the recipient of the radiation only. As may be seen below, the radiation dosage rate may be reduced from 10^{-5} to 10^{-6} roentgens per second by the addition of roughly 30 per cent more lead in a given protective barrier. However, since the value of 10^{-5} roentgens per second is the present accepted tolerance dosage rate, all of our calculations will be based on this figure, and a discussion of the relative merits of the two values will not be entered into.

Although genetic effects were not a consideration during the preparation of the international safety recommendations, it is possible that such a wide margin of safety has been provided that they have hitherto successfully protected against genetic mutations.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] Presented at a meeting of Committee E-7 on Radiographic Testing, Atlantic City, N. J., June 26, 1939.

[2] X-ray Laboratory, National Bureau of Standards, Washington, D. C.

[3] This *Handbook*, and *Handbook 23*, may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a cost of 10¢ each (stamps not accepted), mailed free.

[4] The italicized numbers in parentheses refer to the reports and papers appearing in the list of references appended to this paper, see p. 31.

LEAD PROTECTIVE BARRIERS

Since lead has the highest atomic number of any material readily available and easily worked, it is generally used for protective barriers and the protective value of other materials is referred to lead as a base.

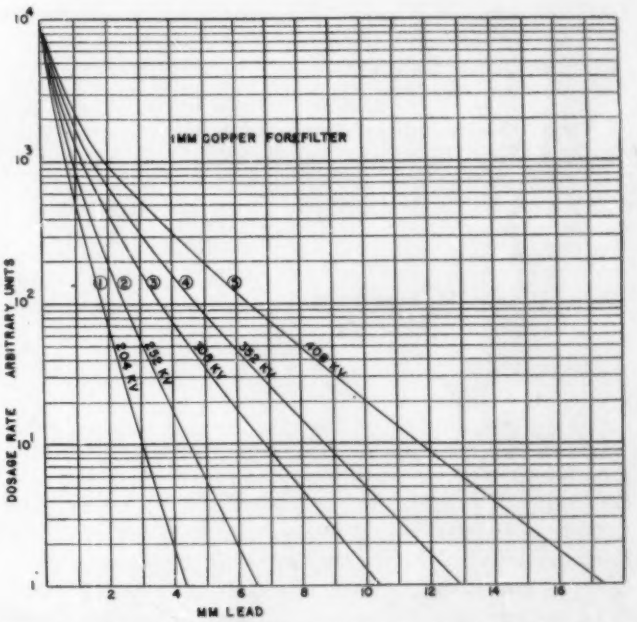

FIG. 1.—X-ray Absorption in Lead (1 mm. Cu + 1 mm. Al fore filter) (Hermann and Jaeger).

Figure 1 gives a set of lead absorption curves in the X-ray excitation range of 200 to 400 kv. produced with a Villard rectifier (*3*) and having an initial filtration of 1 mm. Cu + 1 mm. Al (hence fairly hard radiation).[5] Starting with a relative dosage rate of 10^4, the absorption measurements for the several voltages are carried out until the dosage rate has been reduced to unity.

Table I gives the thickness of lead necessary for adequate protection as prescribed by the International Commission on X-ray and Radium Protection (*2*). It is obvious that the figures can apply only to an incident beam of one given dosage rate at a definite distance from a given X-ray tube. These factors have never been stated in the recommendations, though they have been the subject of numerous separate publications. Hermann and Jaeger (*3*) have presented perhaps the best study of this phase of protection and their work forms the basis of our discussion.

Referring to Table I, it is seen that 4 mm. of lead is required for 200 kv. protection. In Fig. 1 it is found that 4 mm. of lead reduces the dosage rate to about 2, or to 2/10,000 of the incident value. Thus if we assume that the transmitted dosage rate is just 10^{-5} roentgens per second, it follows from Fig. 1 that the incident dosage rate will have been 0.05 roentgens per second or 3 roentgens per minute. If we next assume a somewhat arbitrary average tube output of say 27 roentgens per minute measured at 50 cm. from

[5] The lead thickness required at a given voltage will be slightly greater for constant potential excitation.

the target it is seen that the dosage rate of 3 roentgens per minute will be obtained at a position about 150 cm. from the target—the diminution in dosage rate being governed by the inverse square law.

The protective thicknesses above 200 kv. in Table I are based on Hermann and Jaeger's work; they are self consistent in that they all give the thickness of lead required to reduce the beam produced at any given voltage by the same amount as does 4 mm. at 200 kv. The values below 200 kv. have been found to do likewise by van der Tuuk and Boldingh (*4*) and Glocker and Reuss (*5*). *It is thus seen that the internationally accepted protective lead thicknesses all apply, under average dosage rate conditions, to a point 150 cm. from the target.*

TABLE I.—Mass of Lead Barrier for Adequate Protection.[a]

Potential, kv.	Recommended Minimum Lead Thickness, mm.	Weight of Barrier, psi.
75	1.0	2.4
100	1.5	3.5
150	2.5	5.9
200	4.0	9.5
225	5.0	14
300	9.0	21
400	15.0	35
500	22.0	52
600	34.0	80

[a] Recommendations of International Commission on X-ray and Radium Protection (1937).

In the examples given below we will use an average incident value of 6 roentgens per minute (or 0.1 roentgen per second) at a distance of 100 cm. from the target which will introduce only a slight difference from the figure derived from the international recommendations.

To simplify the calculation of lead thicknesses for different incident dosage rates (as affected by target distance and tube output) Hermann and Jaeger (*3*) have replotted their data, Fig. 2, to show directly the amount of lead which must be inserted in a given beam to reduce the transmitted dosage rate to 10^{-5} roentgens per second. For example, suppose we take the case of an incident beam at 204 kv. and a dosage rate of 0.1 roentgens per second. Referring to curve 1 it is seen that 4.2 mm. of lead is required to reduce the dosage rate to the tolerance value of 10^{-5} roentgens per second. This is seen to be in agreement with the discussion above for the average conditions at 100 cm. If, on the other hand, it is desired to reach the safe tolerance dose after passing through a lead barrier located at a distance of 4 meters from the tube, the incident dosage rate on the lead barrier is then reduced by inverse square law to $\frac{1}{16} \times 0.1$ roentgens per second $= 0.0063$ roentgens per second $= 6.3 \times 10^{-3}$ roentgens per second. Again on curve 1, the point 6.3×10^{-3} roentgens per second corresponds to a required lead thickness of 2.7 mm. to reduce the transmitted radiation to 10^{-5} roentgens per second. If, instead of the average output of 0.1 roentgens per second, the output is, say, 0.033 roentgens per second, then the dosage rate at 4 meters would be reduced to $0.033/0.1 \times 6.3 \times 10^{-3}$ roentgens per second $= 2.1 \times 10^{-3}$ roentgens per second; for which the curve would show a required thickness of 2.2 mm. of lead to reduce the radiation to the tolerance value. It is seen that in this particular voltage range the difference between 2.7 and 2.2 mm. of lead is splitting hairs and that obviously the safe practice is to use the higher figure. Since the economy is slight it would probably be best to use simply a lead thickness of the nearest commercially available value above the higher figure.

At the higher voltages, real economies may be effected by careful consideration of the distance and output factors. Let us take the same conditions at 408 kv., and refer to curve 5, Fig. 2. For an incident dosage rate of 0.1 roentgens per

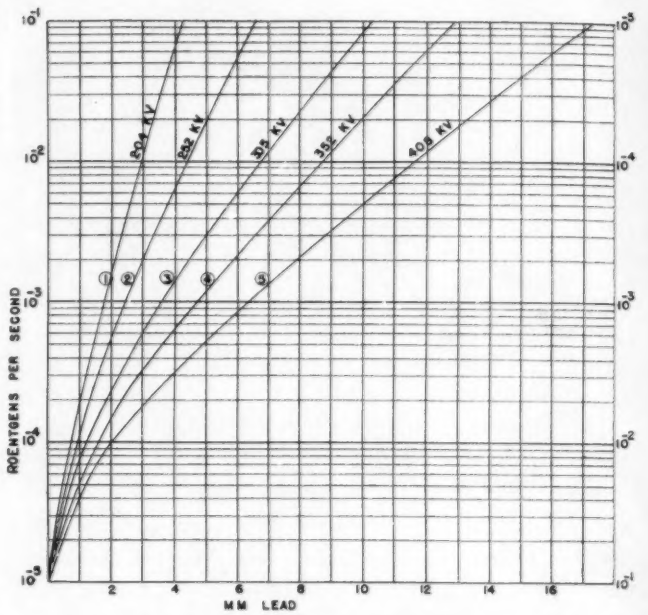

FIG. 2.—Dosage Rate Which Will Be Reduced to the Value of 10^{-5} r/sec by Absorption in the Lead Thicknesses Given in the Abscissae (1 mm. Cu fore filter) (Hermann and Jaeger).

second at 1 meter, a lead thickness of about 17 mm. is necessary to reduce the beam to the tolerance value. At 4 meters the incident dosage rate is again 6.3×10^{-3} roentgens per second, and the required protective thickness is seen to be only 10.5 mm. or a reduction of 35 per cent. If again the tube output at 100 cm. is reduced from 0.1 to 0.033 roentgens per second the incident dosage rate at 4 meters is as before 2.1×10^{-3} roentgens per second and the corresponding protective thickness is 8 mm. of lead or a reduction of 47 per cent. It is thus clear that in the higher voltage ranges very considerable economies may be effected by considering all of the conditions involved in a particular installation.

Use of Hermann and Jaeger's curves in the manner just described applies only to conditions where the initial reduction in X-ray dosage rate is due to scattering from the main beam, tube distance, changed tube output, etc., and is unaccompanied by a hardening of the radiation. Where a decrease in dosage rate is caused by filtering, and hence is accompanied by hardening, the necessary lead thicknesses must be determined beginning at the other end of the curve and using the inverted scale of dosage rates indicated at the right of Fig. 2.

To give an example, suppose we wish to compute the protection necessary in a wall 2 meters away from a lead-covered 400-kv. tube enclosure, where this lead is sufficient to reduce the dosage rate to 10^{-3} roentgens per second at a distance of 1 meter from the enclosure. In this case the radiation is obviously harder than that in the unfiltered beam. The inverse law will give at 2 meters an intensity of $\frac{1^2}{2^2}$

$\times 10^{-3}$ roentgens per second $= 2.5 \times 10^{-4}$ roentgens per second. Using the dosage rates indicated at the right of Fig. 2 it is seen that on the 400-kv. curve to reduce the dosage rate from 2.5×10^{-4} to 10^{-5} will require 17.7 — 10.4 mm. or 7.3 mm. of lead. Had the original radiation been unfiltered, the lead required for protection would have been figured from the left hand set of dosage rates and would be 3.5 mm.

In Table II are given the weights in pounds per square foot of different lead thicknesses; the cost per square foot at an average price of 10¢ per pound; and also an estimate of the installation costs. The figures for installation are, of course, very rough and include the supporting partition of hollow tile or brick with the necessary furring to support the lead. The cost of finishing the plaster, etc., is about the same for all thicknesses. For protection at the lower voltages the cost of the supporting partition is comparable with that of the lead, while for protection at the higher voltages the cost of the lead is predominant.[6]

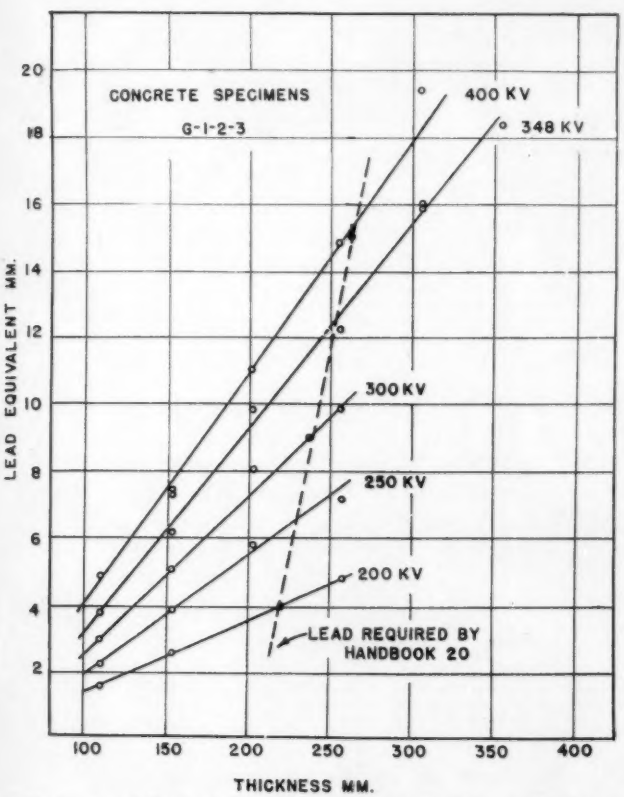

FIG. 3.—Lead Equivalent of Poured Concrete (Singer, Taylor and Charlton).

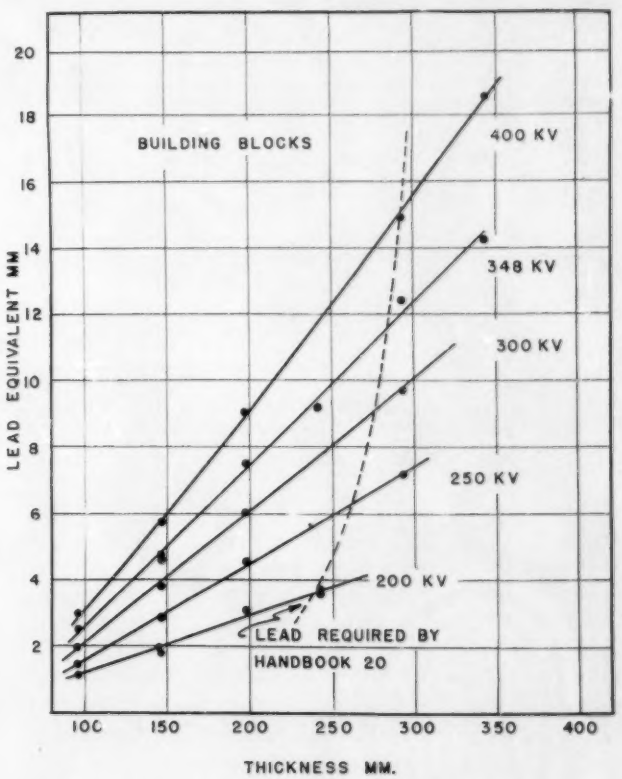

FIG. 4.—Lead Equivalent of Concrete Blocks (Singer, Taylor and Charlton).

OTHER PROTECTIVE MATERIALS

Because of the high cost of lead protection, use of other materials, such as concrete or brick, has been resorted to with some success. Also, concretes "loaded" with barium sand, iron filings or iron ore have been used. However, it is important to emphasize that a lead barrier will provide the lightest installation per given degree of protection (within the voltage range of 50 to 600 kv.). Any of these substitutes will be from 2 to 20 times heavier; but this higher load may be offset by the concrete or brick having definite structural value and thus provide economies in general building construction.

Singer (6) has shown that at a given excitation between 200 and 400 kv. the protective value of concrete is proportional to its density and Kaye (7) has shown proportionality for other materials. We thus have the choice of making a thin wall of dense "loaded" material or a thicker wall of standard unloaded material. The relative costs depends largely upon the geographical location with respect to iron mines or barytes pits.

Figures 3 and 4 give, for poured concrete and concrete blocks, the lead equivalents at different voltages and thicknesses of material. The curves in dashed lines give, on the ordinates, the lead requirements of the International Commission.

The important feature about concrete protective barriers is that their protective efficiency, with respect to lead, increases with both voltage and thickness in the range above 200 kv. Since the thickness is the controllable factor, it is desirable to use only the full thickness necessary for a given lead equivalence. This "optimum" thickness is found to vary only slightly with voltage above 200 kv.

Table III gives the lead equivalents of concrete for the conditions imposed by the international protection recommendations. The next to the last column shows the marked increase in the efficiency of concrete protection with increase in voltage, while the last column shows the decreasing weight ratio of concrete to lead. In installation, the weight ratios

[6] The installation costs above 300 kv. are difficult to estimate and are probably low. It is quite likely that for weights above 20 lb. per sq. ft. a special steel frame or concrete wall construction would be required for support of the lead necessary at the higher voltages. For a ceiling or floor the lead may be simply laid on the floor and then covered with some suitable decking.

may be smaller than shown in the next to the last column since the weight of wall necessary to support the lead must be taken into consideration. It is thus strikingly evident that the desirability of employing concrete as an X-ray protective material increases with voltage.

In a finished building, because of the difficulty of installing and filling the forms, it may not be easy or economical to install solid concrete walls, but in a new building concrete walls are easily made and form a structural member of the building. Costs of concrete walls and floors are given in Table IV.

In our own laboratory, we have found that solid concrete blocks give very satisfactory and economical protection. The blocks were made in standard block molds with cores removed, and of such a dry mix that they could be easily handled after forming. All joints were filled solid with mortar and tests showed a very homogeneous wall. Here it was necessary to install three walls 13½ ft. high; one, 26 ft. long by 6 in. thick; another 14 ft. long by 4 in. thick; and, the third 16 ft. long by 8 in. thick. The total cost of labor and material was $410 and the average costs per square foot are given in Table IV.

Table V shows the lead equivalent for concrete blocks for the conditions imposed by the international protection recommendations. For comparison, the lead equivalents of several other materials are also given.

TABLE II.—Costs of Lead Walls.

Potential, kv.	Weight, psi.	Cost per Square Foot	Installed Unfinished[a]	Installed Finished[b]
100	3.5	$0.35	$0.85	$1.20
200	9.5	0.95	1.45	1.80
300	21	2.10	2.70	3.05
400	35	3.50	4.10	4.50
500	52	5.20	6.00	6.50
600	80	8.00	9.00	9.50

[a] Lead fastened to furring on terra-cotta wall.
[b] Lead covered with lath and plaster.

TABLE III.—Lead Equivalents of Concrete.

Potential, kv.	Recommended Lead, mm.	Concrete Equivalent, mm.	Mass per Unit Area		Ratio, Thickness of Concrete to Thickness of Lead	Ratio, Mass of Concrete to Mass of Lead
			Lead, g. per sq. cm.	Concrete, g. per sq. cm.		
100	1.5	120[a]	1.7	28	80.0	16.5
200	4	220[b]	4.5	53	55.0	11.8
300	9	240[b]	10.2	57	26.7	5.6
400	15	260[b]	17.0	60	17.3	3.5
600	34	300[d]	38.4	65	8.1	1.7
1000	86[f]	.....	97.5	...	...	...
Gammarays	100[e]	540[e]	113.4	130	5.5	1.2
Gammarays	50	270[e]	.....	...	...	...

[a] From Kaye, $\rho = 2.1$.
[b] From Singer, Taylor, and Charlton (*6*), $\rho = 2.35$.
[c] Calculated from Kaye, Binks and Bell (*7*), $\rho = 2.35$.
[d] Extrapolated value from Singer, Taylor, and Charlton (*6*).
[e] From Kaye, Binks and Bell (*7*), 100 mm. applies to 3 g. of radium at a distance of 100 cm. 50 mm. applies to 0.25 g. of radium at a distance of 100 cm.
[f] From Van der Tuuk (*8*) recalculated to accord with International Recommendation.

PROTECTION AGAINST DIRECT RADIATION

Having outlined the methods of calculating the required lead protective thicknesses against direct radiation and indicated the factors involved in the choice of protective materials, we may now take up the more specific problem of protection in the radiographic room. As above, the discussions can be simplified by taking as a working base a tube whose output measured 0.1 roentgens per second at 100 cm. from the target (24 roentgens per minute at 50 cm.).

The calculations given above apply to the direct beam, and while it may be assumed that there is always an object in the beam, and hence the tube output effectively less, it is unsafe to base computations on conditions with an obstructed beam. This reservation applies, of course, to all portions of a room that may be reached by a direct beam (see *N.B.S. Handbook 20,* Paragraphs 305 and 406.)

The best protection in the average X-ray room may be accomplished through application of the inverse square law, for the tube is seldom closer than 3 or 4 meters to the wall which separates it from the operator. Particularly in a new building, it may be easier to place the operator and partition relatively far from the tube than to build a smaller but heavier partition near the tube. In cases where the area of the partition will not be affected by its distance from the tube, the economy of moving it away is obvious. On the other hand, where concrete replaces lead, the savings resulting from shifting the partition away from the tube are slight. Taking the 400-kv. case, it is seen that 15 mm. of lead or 26 cm. of concrete are needed for protection at 2 meters, while 10 mm. of lead or 18 cm. of concrete are needed at a distance of 5 meters (see Fig. 3). The saving in cost and weight by shifting the partition is about 30 per cent for lead; while for concrete, although the weight is also decreased by about 30 per cent, the cost is not reduced by more than 5 to 10 per cent.

Protective barriers can be applied directly to the tube itself, in which case the target-lead distance may be only 10 or 15 cm. Although for a given degree of protection this requires a slightly greater thickness of lead, the amount is far smaller than that necessary for a whole partition or room. Added lead thickness applied directly to the tube lessens that required by the walls, up to the point where the stray radiation from the tube equals the scattered radiation

TABLE IV.—Cost of Concrete Walls and Floors.[a]

Voltage, kv.	Thickness		Cost per square foot of Wall[b]	Cost of Concrete Floor[b]	Cost per square foot of Concrete Block[c]
	cm.	in.			
100	12.0	4¾	$0.63	$0.38	$0.56
200	22.0	8½	0.72	0.47	0.65
300	24.0	9½	0.77	0.52	0.70
400	26.0	10¼	0.79	0.54	0.73
1000	(30.0)	(12)	0.84	0.59	0.80

[a] The values in parentheses are extrapolated values.
[b] Installed during building construction.
[c] Installed in completed building.

TABLE V.—Lead Equivalents of Various Building Materials.[a]

Potential, kv.	Lead, mm.	Concrete, mm.[b] ($\rho = 2.4$)	Concrete Block, mm.[b] ($\rho = 2.05$)	Barium Concrete, mm.[c]		Brick, mm.
				$\rho = 3.2$	$\rho = 2.7$	
75	1.0	80	85	15	...	175
150	2.5	210	220	28	52	290
200	4	220	245	60	100	430
300	9	240	275	105	150	425
400	15	260	290	140	185	450
Gamma rays[d]	50	(242)	(270)	200	225	...
Gamma rays[d]	100	(480)	(540)	400	450	...

[a] Values in parentheses are calculated values. ρ = Density.
[b] Taken from Singer, Taylor and Charlton.
[c] Taken from Kaye, Binks and Bell.
[d] For quantity of radium see Table III.

from objects in the direct beam. This reduction in thickness, of course, does not apply to portions of the room reached by the main beam.

If, with the present-day flexibility of therapy tube mountings, the direct beam may strike almost any portion of the treatment room, full protection against direct radiation in accordance with the discussions above must be arranged. In such a case the tube protection may be reduced to a very low level in so far as it may affect the protection to the operator outside.

PROTECTION AGAINST SCATTERED RADIATION

Thus far the discussion has been limited primarily to protection against direct radiation. But scattered radiation is always present and must be reduced to at least the same end value as the direct. Exact directions for accomplishing this most economically are difficult to formulate because of the uncertainty in the large number of contributing conditions.

Scattering is principally from the test object or floor. That from the test object varies very considerably with field area, so for computation purposes the scattering from the largest area should be taken. Exposure cones (if lead lined) reduce the scattering to a level substantially below that without a cone. Braestrup (*9*), using limiting cones, has given figures (Table VI) for the scattering from a wax phantom irradiated over different field areas with 200 kv. X-rays filtered with 1 mm. Cu +1 mm. Al at 50 cm. focal distance and a dosage rate of 30 roentgens per minute (0.5 roentgens per second).

The last column in the table is taken from a paper by Behnken (*10*) and adjusted to conditions comparable with Braestrup's. The discrepancy between the findings of the two investigators is not surprising when one considers the number of variables in both cases. Braestrup (*9*) has shown for a 20 by 20 cm. irradiated field on wax that the scattering at right angles to the beam is about 0.2 per cent of the dosage rate of the primary beam, and decreases with decrease in field size. It is reasonable to expect that at lower voltages the scattering ratio will not increase, and although the amount of scattering will increase at higher voltages it will take place at a smaller angle to the direct beam, so that the scattering ratio at right angles to the beam will probably not exceed that for 200 kv. Therefore, if we allow a somewhat generous safety factor, a scattering ratio of 1 per cent may be used as a basis for calculating the protection to be provided against the scattered radiation.

We have made similar measurements at the radiographic plant of the Washington Navy Yard. Here the tube was supposedly operated at 220 kv. and 10 ma.; no cone was used. The filtration amounted to about $\frac{1}{4}$ mm. of copper. The beam was directed vertically downward on to a 12-in. steel cube with the exposed surface 0.5 meter from the tube target. Under these conditions the dosage rate measured with a thimble chamber resting atop the block was 1.08 roentgens per second while the dosage rate of the scattered radiation at 1 meter in a direction at right angles to the beam was 3.8×10^3 roentgens per second (measurements were actually made at 2 and 4 meters and reduced to 1 meter). Thus it is seen that the scattered radiation at 1 meter is about 0.3 per cent that of the direct radiation, which is of the same order as Braestrup's figures for the scattering from wax.

Hence by again allowing a generous factor of safety, *a scattering ratio of 1 per cent may be used in metal radiography as a basis for calculating the protection to be provided against scattered radiation.* Scattering measurements made at 180 deg. to the main beam showed a somewhat smaller scattering ratio, so that the 1 per cent figure given above is even further in the safe direction.

It is next seen from Braestrup's figures that the quality of the scattered radiation is substantially softer than that of the incident radiation, and under some circumstances advantage may be taken of this in computing protective thickness.

Below 200 kv., the decrease in penetration of the scattered compared with the direct radiation is not very great, nor are very considerable lead economies to be made by any ordinary means. However, above 200 kv. the quality changes are more marked and the possible savings are greater by whatever means achieved.

The wave length of the scattered radiation at the higher voltages may be computed with sufficient accuracy for our purpose by means of Compton's simple scattering formula

$$\lambda_\Theta - \lambda_o = \Delta_\lambda = 0.0243\ (1 - \cos \Theta)$$

where λ_o and λ_Θ are the wave lengths of the incident and scattered radiation respectively and Θ is the angle between the direct and scattered beam ($\cos \Theta = 0$ at 90 deg.). Table VII gives, for a number of excitation voltages, the minimum wave length of the primary beam, the scattered beam, and the voltage equivalent to the minimum wave length of the scattered radiation. The possible effect of pair production is neglected.

TABLE VI.—X-ray Scattering from a Wax Phantom Measured at 1 meter from the Center of the Incident Beam. (200 kv., 30 roentgens per minute at 50 cm.)

Field Size, cm.	Roentgens per Second at 1 Meter	Ratio to Incident Beam, per cent[a]	Quality, mm. (H.V.L. Cu)	Equivalent Voltage (Constant); kv.[c]
20 by 20	0.0011	0.22	0.42	130
10 by 15	0.00046	0.09	0.50	135
6 by 8	0.00019	0.04	0.62	160
15 by 15[b]	0.003	0.6	0.64	...

[a] Quality of incident beam, 0.72 mm. Cu. (H.V.L.).
[b] From paper by Behnken.
[c] Very rough values.

It is at once apparent that the relative softening (lowering of the equivalent excitation voltage) of the radiation by scattering is appreciable at 200 kv. and increases very rapidly above 200 kv. At 510 kv., for example, the scattered radiation has a quality equivalent to only half that voltage while at 1000 kv. the equivalent voltage of the 90 deg. scattered beam is only a third that of the direct beam. When computing, therefore, the lead barriers for scattered radiation,

TABLE VII.—Minimum Wave Length and Equivalent Voltage of X-rays Scattered at 90 deg.

Excitation Voltage, kv.	λ, min., Å (Primary)	λ, min., Å (Scattered)	Equivalent Voltage, kv.
100	0.1234	0.1477	84
200	0.0617	0.0860	144
300	0.0412	0.0655	189
400	0.0309	0.0552	222
510	0.0243	0.0486	255
1000	0.0123	0.0365	340
1500	0.0081	0.0324	380

the absorption of the lead is to be taken from the curves at the voltage corresponding to that of the scattered radiation and not the direct radiation.

Two examples will illustrate the combined uses of tables VI and VII.

Case 1.—200 kv., 0.1 r. per sec. at 1 mm.; compute the thickness of lead wall 4 meters from test object in direction at right angle to beam.

From the earlier discussion; dosage rate of scattered beam at 1 meter from object = 1 per cent × 0.1 r. per sec. = 10^{-3} r. per sec.

From the inverse square law; dosage rate at wall = $1/4^2 \times 10^{-3} = 6.3 \times 10^{-5}$ r. per sec.

Using the 200 kv. lead absorption curve (Fig. 2) it is found that a further thickness of less than 0.6 mm. of lead is required to reduce the dosage rate to the tolerance value on the other side of the wall.

Case 2.—400 kv., 0.1 r. per sec. at 1 meter; compute the necessary thickness of lead 4 meters from test object in direction at right angles to beam.

dosage rate of scattered beam at 1 meter from object = 1 per cent × 0.1 r. per sec. = 10^{-3} r. per sec.

$$\text{dosage rate at wall} = \frac{1}{4^2} \times 10^{-3} = 6.3 \times 10^{-5} \text{ r. per sec.}$$

The effective voltages of scattered radiation is 250 kv. From Fig. 2 it is found that 0.7 mm. of lead is required to reduce the dosage rate to the tolerance value of 10^{-5} r. per sec. on the other side of the wall. (Using the 400 kv. curve would give a value 1.5 mm. for the lead required.)

In both cases it is seen that, compared with direct radiation, very great reductions in the wall thickness for adequate protection against scattered radiation may be made. In the 200-kv. case the thickness of lead as compared with that necessary for the direct beam is 17 per cent, and for the 400 kv. case, 8 per cent. It has been assumed in these cases that stray radiation through the tube shields was reduced to a level substantially below that of the radiation scattered by the object.

The above discussion has dealt only with the modified scattered radiation calculated by Compton's formula. There will, of course, be a small component of unmodified radiation scattered at 90 deg. to the direct beam. By consideration of the form factor in the higher voltage region (400 to 1000 kv.) Bethe has calculated the unmodified electron scattering from the *K* shells. He finds this to be, for lead, less than 5×10^{-5} times that of the direct beam and for concrete less than 5×10^{-9} times the direct beam. For body tissue the fraction will be even smaller. Contributions from the *L* and *M* shells and nuclear scattering will all be less than the values above. Thus, considering the extreme case of scattering by lead if we start with an incident dosage rate of 0.1 roentgens per second, the dosage rate of the unmodified radiation at 90 deg. will be less than 10^{-6} roentgens per second. Since this is already below the tolerance dose no additional protection need be added therefor.

Protective barriers close to the target, have particular value in the case of supervoltage radiation—above 400 kv.—where immense quantities of protective material would be required if applied merely to the walls of a room. At excitations in the region of 1000 kv. the target is usually at the end of a tube which has a length 5 to 10 times its diameter. By surrounding the target tube with some 3 in. of lead (the required amounts are not yet known exactly) the escape of radiation is limited to the useful treatment beam and a useless beam directed back along the axis of the X-ray tube. By giving some consideration to the direction of these beams it is possible to design an installation in which all radiation striking a protective wall will have been scattered one or more times through a total angle of at least 90 deg. The scattered radiation is thereby reduced to a hardness in accordance with Table VII, which requires relatively less protection.

A practice has grown up in this country of using protective barriers extending only 7 ft. up from the floor instead of to the ceiling. In some cases this provides adequate protection but the practice is dangerous, because of radiation scattered by the air and ceiling to the outside of the partition where the operator is located. Braestrup (9) has studied several such installations and finds that the scattering behind a 7-ft. partition in therapy installations is 10 to 20 times as great as behind the same partition when extended to the ceiling.

We have checked Braestrup's findings, at the above-mentioned Navy Yard installation. The 12-in. steel cube was irradiated in the center of a 20 by 20-ft. enclosure made of $\frac{1}{8}$-in. lead panels 6 ft. 6 in. high. At a point 4 ft. from the wall (15.4 ft. from the tube) the dosage rate was 3×10^{-6} roentgens per second, whereas a full $\frac{1}{8}$ in. lead enclosure should have reduced the scattered radiation at this point to about 5×10^{-7} roentgens per second. Here, as in the therapy installation, the full lead wall would have added a factor of about 10 to the safety, although in this case the dosage rate was below the tolerance value anyway.

At a position of 26 ft. from the tube the full lead wall would have added a factor of about 15 to the safety. This seemingly contradictory result is due to the large angle scattering from the air above that general vicinity. The particular X-ray installation was located in a metal frame building having a 30-ft. ceiling. A ceiling of half that height would very substantially increase the radiation scattered down behind a 7-ft. barrier.

An interesting feature in the Navy Yard installation was the protection of a crane operator about 20 ft. above the open-top radiographic enclosure. The operator's cab was lined with $\frac{1}{8}$ in. of lead on the bottom and up about 3 in. on the sides. While in a position immediately over a radiographed casting, the dosage rate within the cab was about $\frac{1}{5}$ the tolerance value. Six inches beyond the edge of the cab the dosage rate was 3 times the tolerance value. In other words, the operator was within a continuously safe field of radiation so long as he did not lean out over the edge of the cab.

LOCATING X-RAY TUBES IN EXPOSURE ROOMS

Where limiting the flexibility of the tube mounting does not interfere too greatly with the exposure flexibility, the room protection may usually be simplified by careful choice of the tube position, tube mounting, and possible angulation of the beam. It is not feasible to attempt to discuss all the possible conditions under this head, nor does it seem possible at the moment to set up any simple rules to cover cases in general. Braestrup (9) has discussed a group of therapy rooms with respect to their protection and reference should be made to his paper. We will give simply an analysis of a typical problem presented to us for solution recently.

While this discussion is based primarily on a therapy installation all of the problems may apply directly to a metal radiographic plant.

The question involved the installation of a 400-kv., 12-ma.

equipment in a building already constructed. The equipment was to be placed in an outside corner room because outside walls require no protection.[7] The selected disposition of equipment and occupancy is shown in Fig. 5. The position selected for the operator was the only feasible one. The room below required protection at the floor for full-time occupancy. The ceiling, however, was next to the roof; consequently, it and the outside walls needed no protection. The diagnostic room was assumed to be occupied by staff personnel 20 per cent of the 7-hr. day, permitting 5 times the adopted tolerance dose for continuous exposure.[8] We have a choice of positions 1 and 2 for the X-ray tube; in which in either case it is in a lead-lined tank. In position 1 the direct beam can be swept through an angle φ_1, in the vertical east-west plane; and, in position 2, through the more restricted angle φ_2. With the X-ray tube located in position

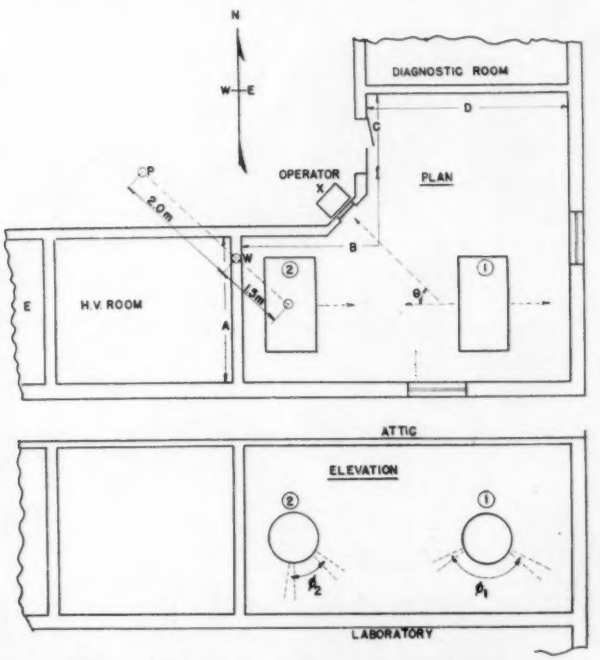

FIG. 5.—Typical Deep Therapy Room Layout.

1 there is then the possibility of pointing the direct beam in the general direction of the operator. Under this condition the angle Θ between the direct and scattered beam toward the operator is only about 45 deg. in which the scattered radiation would be substantially more intense than given in Table VI. In this case a value of 10 per cent of the main beam may be assumed. The hardness of the scattered radiation is also greater than shown in Table VII because the angle between the direct and scattered beam is 45 deg. instead of 90 deg. To err on the safe side, lead absorption values are taken as for the direct beam instead of the scattered from the 400 kv. curve in Fig. 2. The distance between partition *B* and scattering body is about 8 ft. (2.5 meters). Starting with the tube output of 0.05 roentgens per second at 100 cm., the scattered radiation, already assumed as 10 per cent at 1 meter, will be about 0.10×0.05 roentgens per second $= 0.005$ roentgens per second. At the partition *B* the dosage rate will be $\frac{1^2}{2.5^2} \times 0.005$ roentgens per second $= 8 \times 10^{-4}$ roentgens per second. From the 400-kv. curve in Fig. 1 it is found that to reduce the dosage rate at this point to the tolerance value, the lead partition must be about 6 mm. thick (or 15 cm. of concrete). Had allowance been made for the softening in quality of the scattered radiation, the lead partition might be fixed at 3 mm.

As a rule it is undesirable to permit the direct beam to point even in the general direction of the operator. For that reason, position 2 for the tube was considered. Here the tube and test object are both nearer to the operator (2 meters) but the direct beam cannot possibly point in a direction closer than 90 deg. to the operator. Calculating the scattering as before we have 1 per cent of 0.05 roentgens per second $= 0.0005$ roentgens per second at 1 meter at right angles to the direct beam, and $\frac{1^2}{2^2} \times 0.0005$ roentgens per second $= 1.2 \times 10^{-4}$ roentgens per second as the dosage rate at the position of the operator. Using the 250-kv. curve in Fig. 2, it is seen that the required lead barrier *B* should be 1.0 mm. thick (or not making allowance for the change in quality by scattering and using the 400 kv. curve, 2.2 mm. thick).

It is seen, therefore, that, with 2.2 mm. of lead instead of 6 mm., there is a distinct gain in placing the tube at position 2 instead of position 1, not to mention the added safety factor arising from the impossibility of the beam being directed toward the operator. The solution here assumes adequate protection in the tube shield; if this does not obtain, the protection on partition *B* should be increased correspondingly. In shifting from position 1 to 2, there is but a slight decrease in the required protection on partition *D*. To calculate this protection we may again start with a scattered dosage rate (at 1 meter) of 0.0005 roentgens per second and make an inverse square law adjustment which gives the dosage rate at the distance 3.3 meters of the partition *D*. We derive $\frac{1^2}{3.3^2} \times 0.0005$ roentgens per second $= 5 \times 10^{-5}$ roentgens per second at *D*. On the 400-kv. curve of Fig. 2 this calls for 1.2 mm. of lead, or for the softer radiation on the 250 kv. curve 0.6 mm. of lead.

The door *C* should have about the same amount of lead as the partition *B* (2.2 mm.), since the operator is located nearby.

The protection on the west might be divided merely between walls *A* and *E* because wall *E* serves another deep therapy room and is $3\frac{1}{2}$ meters away. Assuming a somewhat arbitrary position for the working personnel such as *P*, 3.5 meters away from the tube, and also that all the protection to this position be applied on wall *A* alone, the scattering, as above, from the tube at position 2 is 5×10^{-4} roentgens per second at 1 meter and hence $\frac{1^2}{1.5^2} \times 5 \times 10^{-4}$ roentgens per second $= 2.2 \times 10^{-4}$ roentgens per second at the position *W* of the wall. At *P* the permissible dosage rate is

[7] This is not always the case; consequently, caution must be exercised when considering the protection on outside walls.

[8] It may be the safest practice to assume that a room occupied at all is occupied full time, but we give the other case to indicate how it may enter the computations.

10^{-5} roentgens per second so that at position W it can be

$$\frac{3.5^2}{1.5^2} \times 10^{-5} \text{ roentgens per second} = 5.5 \times 10^{-5} \text{ roentgens per second.}$$

Referring to the curve for 250 kv. in Fig. 2, we find that to reduce the dosage rate from 2.2×10^{-4} to 5.5×10^{-5} an 0.8-mm. lead thickness is required. (By not considering the quality change, and therefore using the 400-kv. lead-absorption curve, it is found that 2.0 mm. of lead will provide adequate protection.)

Since the beam may be assumed to be directed toward the floor the greater part of the time, and since the room below is occupied, the floor should be adequately protected with lead or its equivalent. Directly beneath the tube and extending some 2 meters to the east, the dosage rate of the direct beam (150 cm. minimum target distance) will be no more than

$$\frac{0.5^2}{1.5^2} \times 0.05 \text{ roentgens per second} = 5.5 \times 10^{-3} \text{ roentgens per second,}$$

where 0.05 roentgens per second is the dosage rate at a distance of 0.5 meters. Referring to the 400-kv. curve it is seen that 10 mm. of lead is necessary to provide adequate protection. At the 2-meter limit (target distance 2.5 meters) the dosage rate will be about

$$\frac{0.5^2}{2.5^2} \times 0.05 \text{ roentgens per second} = 2 \times 10^{-3}$$

which requires 8.0 mm. of lead protection. The lead could perhaps then be graded in small steps, although this might introduce difficulties in making a smooth floor. As seen from Fig. 3, a 25-cm. (10-in.) concrete floor would provide adequate protection under all conditions.

TABLE VIII.—Lead Equivalents of Protective Materials at Low Voltages.

Excitation Voltage, kv.	Recommended Lead, mm.	Lead Equivalents, mm.		
		Barium Plaster[a] $\rho = 3.5$g. per cu. cm.	Concrete $\rho = 2.1$g. per cu. cm.	Brick $\rho = 1.5$g. per cu. cm.
50	0.5	4	50	80
100	1.5	7	100	200
150	2.5	24	175	400

[a] 2 parts coarse $BaSO_4$, 2 parts fine $BaSO_4$, 1 part cement.

PROTECTION AT EXCITATIONS BELOW 100 KV.

The problem of protection below 100 kv. is relatively simple and needs almost no discussion beyond that given in *Handbook 20*. For protection against a direct beam, lead thicknesses up to 1.5 mm. are sufficient and a 50 per cent reduction in thickness leads to no great saving. In this region protection by means of brick, barium plaster, etc., finds considerable application. Table VIII gives the lead equivalents for several of the common construction materials at different low voltages. These are taken from Kaye (7).

From this table it is seen that up to 100 kv. any of the materials listed will provide adequate protection without introducing constructional difficulties. A 200-mm. (8-in.) brick wall should suffice, but care must be taken to insure completely filled mortar joints. At 150 kv. about 1 in. barium plaster is required and difficulties may be encountered because of its weight (16.7 lb. per sq. ft. as compared with 5.9 lb. per sq. ft. for lead) and mode of application. Brick at this voltage is not desirable because of the excessive thickness required. Lead or concrete appear the more logical materials.

PROTECTIVE TUBE ENCLOSURES

The question of how far to carry the protection as applied directly to the tube enclosure is still open. It has already been mentioned for high-voltage tubes, and in all the preceding discussions it has been assumed, that the tube enclosure is sufficient to reduce the transmitted dosage rate to a value below that scattered from the test object. However, the problem in the low-voltage range is inherently different from that in the high-voltage range where we have suggested that the tube enclosure be such as to reduce the stray dosage rate to a value of about 1 per cent of the direct beam at the position of the test object.

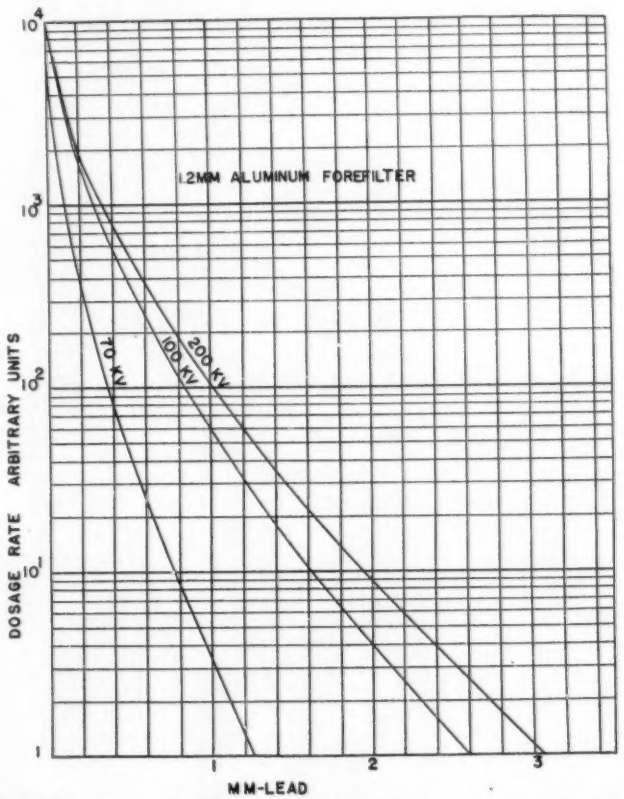

FIG. 6.—X-ray Absorption in Lead at Low Excitation Voltages.

Gross (*11*) has made some measurements of the scattering from a wax phantom reaching a point 1 meter away in a direction at right angles to the beam, the tube being operated at 80 kv. and fully protected. With and without a cone he found the scattered dosage rate respectively 0.03 and 0.1 per cent of the direct beam incident on the phantom at a 60-cm. skin-target distance. This is in reasonably good agreement with the percentage of scattering discussed so we may be justified in taking a maximum permissible dosage rate of scattering, amounting to 0.05 per cent that of the main beam. Referring to the curve in Fig. 6 giving the lead absorption at low voltages it is seen that lead of about 0.9 mm. thickness around the X-ray tube would provide the necessary amount of protection to the radiologist when using 70-kv. excitation. Since, in any case, the quantities of lead involved in 75-kv. protection are not large this should not be an ex-

cessive demand. We are not in a position at the present time to reach any final conclusions in this regard, but these figures are believed to be on the safe side.

REFERENCES

(1) Radium Protection (N. B. S. Handbook 23), *Radiology*, Vol. 31, p. 481 (1938).
(2) International Recommendations for X-ray and Radium Protection, Fifth International Congress of Radiology, 1937, *Radiology*, Vol. 30, p. 511 (1938).
(3) H. Herrmann and R. Jaeger, "Uber den Strahlenschutz bei harten Röntgenstrahlen," *Strahlentherapie*, Vol. 41, p. 321 (1931).
(4) J. H. van der Tuuk and W. H. Boldingh, "Die Bleischutzdicken in den deutschen Strahlenschutzvorschriften," *Fortschritte auf dem Gebeite der Röntgenstrahlen*, Vol. 41, p. 965 (1930).
(5) R. Glocker and A. Reuss, "Strahlenschutzmessungen," *Fortschritte auf dem Gebeite der Röntgenstrahlen*, Vol. 40, p. 501 (1929) and Vol. 42, p. 651 (1930).
(6) G. Singer, L. S. Taylor and A. L. Charlton, "Concrete as a Protective Material against High-Voltage X-rays," *Journal of Research*, Nat. Bureau Standards, Vol. 21, p. 783 (1938) (*Research Paper 1155*).
(7) G. W. C. Kaye, W. Binks and G. E. Bell, *British Journal of Radiology*, Vol. 11, p. 676 (1938).
(8) J. H. van der Tuuk, "Messungen an Röntgenstrahlen bis 1 million volt," *Fortschritte auf dem Gebeite der Röntgenstrahlen*, Vol. 58, p. 83 (1938).
(9) C. B. Braestrup, "A Stray Radiation Survey of 20 High-Voltage X-ray Installations," *Radiology*, Vol. 31, p. 206 (1938).
(10) H. Behnken, "Dosimetrische Untersuchungen uber Röntgenstrahlenschutz und Strahlenschutzrohren," *Fortschritte auf dem Gebeite der Röntgenstrahlen*, Vol. 41, p. 245 (1930).
(11) M. G. Gross, Personal communication.

Properties of Rubber Revealed by Mechanical Tests[a]

By Felix L. Yerzley[1]

SYNOPSIS

Elasticity, energy, resilience, and hysteresis loss are defined in an effort to clarify terminology essential to a discussion of mechanical tests. Several familiar test methods are examined with respect to the measurement of elastic properties. Tests included in the survey are tension tests, compression set, rebound tests, the compression oscillograph, the Goodrich Flexometer, and hardness tests. An attempt is made to show the correlation between the tests and the needs they are intended to fill, and to point out shortcomings and ways of overcoming them.

THE mechanical tests of rubber and rubber-like materials depend upon the deformation of test specimens under an applied load. They may be run to determine the fundamental relationships between force, deformation, and time under a variety of conditions, or they may be run for comparative purposes only under conditions too complicated to yield fundamental information. Tests of the former type yield properties of materials while tests of the latter type supply data on over-all performance of some particular shape of test specimen under unique conditions. As the science of rubber testing advances, it will become increasingly possible to predict performance under complicated conditions from measurements of its fundamental properties. The degree of faith we can have in such predictions will indicate how far we have traveled along the road from the empirical art of rubber technology to the more general advantages of a science.

This paper is intended primarily to stimulate thought on the significance of some of the common mechanical tests of rubber. To do so it is necessary to define clearly the meaning of terms frequently used quite loosely in rubber technology. In the following paragraphs an attempt is made to clarify the meaning of the word elasticity and related terms. The definitions will apply to familiar load-deformation relationships regardless of the type of loading in shear, compression, or tension.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[a] Presented at the Forty-second Annual Meeting, Am. Soc. Testing Mats., Atlantic City, N. J., June 26-30, 1939.

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ELASTICITY

The application of force to any physical body changes either its shape or volume, or both. In the case of rubber or rubber-like synthetic materials, it is known that in most practical cases the change of volume as the result of an applied force is negligible. The change of shape under the influence of applied forces, however, is unique in its magnitude. Few substances can be deformed without rupture to the same extent as rubber or its physical brothers; none can be deformed to such a high degree and regain original dimensions so completely. The characteristic recovery of rubber-like materials causes them to be called *elastic*.

A material is perfectly elastic when its load-deformation characteristics are repeated point for point as the load is removed. In terms of graphic representation, the load-deformation curve must be retraced exactly and completely as the load is removed. The statement applies only if the test is made under adiabatic conditions, since modification of the load-deformation curve would result from gain or loss of heat during the loading-unloading cycle.

ENERGY

When a constant force F acts through a distance S, the energy expended is their product, $F \times S$. If the force is not constant but varies with distance the general expression for mechanical work is used:

$$\text{Energy} = \int_{S_1}^{S_2} F dS$$

In either case the energy is expressed in terms of force times a distance, for example, in inch-pounds or dyne-centimeters (erg). Energy is found from a load-deformation curve by measuring the area under the curve and multiplying it by the factor derived from the scale used on the coordinate axes. In this way the area is converted to its equivalent energy in work units. When a test includes both loading and unloading of a test specimen, the area under the loading curve represents the work expended on the test specimen by the machine; the area under the unloading curve represents the energy returned to the machine by the test specimen.

HYSTERESIS

Most materials do not trace the same curve on loading and unloading. The discrepancy results from failure of the material to recover its dimensions instantaneously. The failure to recover may be temporary or permanent, or a combination of temporary and permanent deformation. Mathematically:

$$\text{Hysteresis loss} = \text{Energy expended in loading} - \text{Energy returned in unloading}$$

$$\text{Percentage hysteresis loss} = \frac{\text{Hysteresis loss} \times 100}{\text{Energy expended in loading}}$$

The hysteresis loss of a perfectly elastic substance is zero.

RESILIENCE

The energy returned to a test machine by the test specimen on unloading is the resilience of the test specimen. Resilience is commonly expressed as a percentage of the energy expended during loading. Percentage resilience is thus synonymous with efficiency:

$$\text{Percentage resilience} = \frac{\text{Energy returned in unloading} \times 100}{\text{Energy expended in loading}}$$

The resilience of a perfectly elastic substance is 100 per cent.

It is evident from the foregoing that under adiabatic conditions for any given cycle of loading and unloading:

$$\text{Percentage hysteresis} + \text{Percentage resilience} = 100.$$

METHODS OF TESTING

In most applications of rubber, the individual physical and chemical factors contributing to the over-all performance are so numerous and inseparable that the industry has acquired a preference for tests which duplicate some particular type of service as closely as possible. These tests are so involved that a pertinent discussion of fundamental properties appears to be quite impossible. Among these might be included abrasion tests and tests for resistance to flex cracking. There are other tests, more closely related to fundamental conceptions, which are the primary concern of this paper. Each of these gives at least qualitative information regarding some fundamental property. Some give quantitative information, but the test conditions are not necessarily the best possible selections. To illustrate this statement, a few tests will be briefly examined. No attempt is made to cover the field, but a few representative tests have been selected either because they are commercially important or because they are of timely technical interest.

Tension Testing (A.S.T.M. Tentative Method D 412 – 36 T).[2]—Intended as a comparative test between stocks and as a criterion of cure under standardized conditions, tension testing is perhaps the most important control test in the industry. However, the test is subject to misinterpretation and has probably caused considerable misunderstanding between rubber technologists and technicians in other fields.

There are two important reasons why stress-strain data obtained by the standard test are primarily of value only to rubber technologists. The first is that the data are obtained over an extreme range of deformation not ordinarily encountered in service. Except for a very small class of articles, rubber is used less for its ability to stretch more than 500 per cent than for its ability to stretch up to 50 per cent. Usually flexibility and high resilience are the primary requirements, and ability to survive extreme deformations of secondary importance. The second factor limiting the general usefulness of the standard stress-strain test in tension is that changes occur in the stress-strain curve as the result of repeated cycles of loading and unloading. For the sake of laboratory economy it may be necessary to standardize on the first loading of test specimens for the determination of moduli, but the values obtained in this way may be quite remote from values after several cycles of loading and unloading. We are familiar with the necessity of running rebound tests four or five times before the data obtained are constant from trial to trial. The changes caused by stretching rubber several times before taking final tensile data are no less real. Therefore, the properties that are measured, though characteristic, are but temporary and of limited usefulness with reference to practical conditions.

The prescribed rate of pull is 20 in. per min. for the power-driven clamp in the testing machine. Inasmuch as data are recorded not for the elongation of the test specimen as a whole but for the elongation of the rubber between bench marks on a constricted portion of the test specimen, the definite specification of machine speed does not mean that the actual speed of elongation of the test specimen has been standardized.[3] To correct this difficulty, machines might be designed to run at such a speed that the bench marks would be separated at a definite rate. For properly vulcanized materials, the rate of pull is not as important as it is for under-vulcanized or partially plastic materials for which appreciable deformation under load with the progress of time is characteristic.

Compression Set (A.S.T.M. Tentative Methods of Test D 395 – 37 T).[4]—In the A.S.T.M. compression set test, a disk $\frac{1}{2}$ in. high and 1.129 in. in diameter is spring loaded at room temperature under 400 psi. The test specimen and spring assembly are then placed in an oven for 22 hr. at 70 C. At the end of 22 hr., the test specimen is removed from the spring assembly as quickly as possible and is allowed to cool and recover for 30 min. at room temperature. At the end of this recovery period its net change in height is recorded as a percentage of the original height.

The intent of this test is to measure departures from perfect elasticity by a combination of two severe conditions: (*a*) overloading and (*b*) elevated temperature. Two factors which are unknown quantities in the application of this test are (1) the change of modulus resulting from temperature change and (2) the amount of plastic flow introduced by heating. Usually the end surfaces of the test specimen after removal from the loading device are decidedly concave, and the significance of the result is further masked by this irregularity.

It is apparent that the measurement of compression set by the A.S.T.M. method evaluates no single property of rubber and is not subject to clear interpretation. The load conditions may roughly approximate those occurring in a limited number of gasket or mounting applications, but the end measurement is not obviously related even to the satis-

[2] Tentative Methods of Tension Testing of Vulcanized Rubber (D 412 – 36 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part I, p. 1105 (1936); also 1938 Book of A.S.T.M. Tentative Standards, p. 1287.

[3] The rate of elongation can be more closely controlled by following the European practice of using ring test pieces, but the stresses are more complicated.

[4] Tentative Methods of Test for Compression Set of Vulcanized Rubber (D 395 – 37T), *Proceedings*, Am. Soc. Testing Mats., Vol. 37, Part I, p. 1127 (1937); also 1938 Book of A.S.T.M. Tentative Standards, p. 1334.

factory performance of these. The test may be quite useful in the writing of specifications for a given composition which has been found by suitable tests to be satisfactory. However, it is unwise practice to reverse the procedure and select a composition on the basis of the test except for special service conditions approximating those of the test. In particular, this test cannot be substituted for long-time tests of drift or creep of compositions intended for supports in vibrating structures.

Rebound Tests for Resilience.—Many arrangements of rebound apparatus are used to measure the percentage resilience of compositions. In these a weight is released from an elevated position and falls under the action of gravity to strike a test specimen. After impact, the weight rebounds to recover part of its original elevation. The height recovered by the weight on rebound when divided by its original height above the test specimen gives a fraction for resilience which may be expressed in per cent. Hysteresis may, therefore, be obtained by subtracting the percentage resilience from 100. The figure obtained in this way will include the frictional losses of the machine and any loss at the interface between the test specimen and the impacting surface.

A particularly successful form of the apparatus appears to be the pendulum type which is represented, for example, by Schob's machine manufactured by Schopper[5] in Germany. A 250-g. hammer swinging on a 20 cm. radius falls through an arc to strike a slab mounted on the vertical surface of the base of the machine. The energy of the impact can readily be calculated. The distribution of the energy in the test specimen, however, cannot be determined since neither the volume of the rubber distorted by the impact is measured nor is the distribution of stresses in the sample known. The loading conditions are irregular because of the spherical shape of the hammer. At the instant of maximum penetration of the hammer into the rubber, the stress is maximum at the center of the hammer and gradually decreases to zero at points sufficiently removed from the center. The value of the stresses also varies from sample to sample depending upon the hardness of the compositions even though the same impact energy is used for each test. The influence of this inherent variation in the loading conditions of the test can be investigated qualitatively for any given sample by determining the relationship between the rebound values and the elevation from which the hammer is released. Quantitative interpretation in terms of the elastic characteristics of the sample is not practical. The test is useful for a comparison of similar compositions of about the same hardness, since the load conditions will then be similar. Comparison of stocks of widely different hardnesses may be misleading.

In the Schopper test the rebound is rapid, so the hammer is in contact with the test specimen for a very short time, perhaps for as little as a thousandth of a second. This is significant, for compounds which appear quite resilient in a rapid test sometimes show much lower resilience in a slower test. Complete reversals in the order of resilience have been observed in tests on the Schopper pendulum and the oscillograph discussed below.

Oscillograph.[6]—The original purpose of the machine was to evaluate the properties of compounds used for rubber supports. A compressive load is applied either statically or dynamically to a pellet $\frac{3}{4}$ in. in diameter and $\frac{1}{2}$ in. high and the relationships between the load, compression and time can be measured. Static loading and unloading may be determined by recording percentage compression resulting from application of known loads expressed in pounds per square inch. The energies involved in loading and unloading may also be determined under these essentially static conditions and, finally, the gradual compression of a test specimen under a given fixed load with time. The data obtained in this way are applicable to the preliminary design of rubber mountings. It is not sufficient, however, to know what the characteristics are under static conditions since the primary justification for rubber mountings is their suitability to the isolation of shock and vibration which are dynamic in character. For design with reference to dynamic applications it is also necessary, therefore, to know the dynamic properties of the material including the modulus and damping action. These are derived from an oscillogram, which is an autographic record of oscillations imparted to a lever of known moment of inertia subsequent to absorption of a known impact by a test specimen of the vulcanizate under test. The particular value of the oscillograph is that it yields data under definitely recognizable conditions which can be mathematically related to actual application of rubber cushioning devices, and in addition it has value as a general laboratory test, particularly for record purposes.

Goodrich Flexometer.[7]—A test cylinder 1 in. high is subjected to a known average compressive load by means of a lever arrangement. The upper platen of the machine is caused to vibrate vertically through a definite stroke at a known frequency.[8] The load, the stroke, and the frequency can be adjusted for any test, but having once been established for a test, they are maintained at the same value until the end point is reached. Mechanical working of the compound in this manner would cause no increase of the temperature of the test specimen if its resilience were 100 per cent. Since no compound meets this ideal, all tests result in a rise in temperature of the test specimen. A thermocouple laid between a hard rubber disk on the lower platen of the machine and the end of the test specimen is used to follow the temperature rise at an arbitrary point.

It is essential to the proper performance of the flexometer that the lever be free from the vibration impressed upon the test specimen. Practically, this is accomplished by suspending equally heavy weights at each end of the lever. These increase the inertia of the lever system without affecting the load on the test specimen. By increasing the inertia of the lever, its natural period of vibration is given a length of several seconds. At a nominal speed of 1800 r.p.m. (actual speed about 1720 r.p.m.), there are 30 complete cycles per second. Since this frequency is high in comparison with the natural frequency of the lever, the lever remains undisturbed by the vibration of the test specimen.

In comparison with the service of a tire, the following

[5] K. Memmler, "Science of Rubber," American Edition, p. 571, Reinhold Publishing Corp., New York City (1934).

[6] Felix L. Yerzley, "A New Oscillograph for Routine Tests of Rubber and Rubber-Like Materials," *Proceedings*, Am. Soc. Testing Mats., Vol. 39 (1939).

[7] E. T. Lessig, "The Goodrich Flexometer," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 9, p. 582 (1937).

[8] The St. Joe Flexometer imposes vibration in shear. See paper by R. S. Havenhill and W. B. McBride, "A New Laboratory Machine for Evaluating Breakdown Characteristics of Rubber Compounds," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 7, p. 60 (1935).

points are pertinent: if the radius of a tire from hub center to the road is 15 in., 670 load cycles (loading and unloading) per minute would correspond to a road speed of 60 m.p.h. The test is accelerated, therefore, in regard to frequency. However, since the angle of contact between the tire and the road at any instant is a small fraction of the 360 deg. around the hub, most of the actual loading and unloading at any point occurs more rapidly than it does in the test.

The range between maximum and minimum load on any portion of tire tread during each revolution is from maximum pressure of the tire on the road to zero when the tire is not in contact with the road. The maximum is determined by the weight on the wheel, the inflation of the tire, the characteristics of the tread compound, tire design, and other complicated factors not measurable or subject to duplication in a test. In the test, the specimen is subjected to an average load, as is the tread in service, but the specimen is under compression at all times, whereas the load on a tread is zero most of the time. Since the maximum instantaneous load borne by a tire tread is determined in part by the mechanical characteristics of the compound, it seems reasonable to allow the maximum load to be obtained in the same way in the test.

With respect to mathematical analysis, the temperature rise of a compound vibrating under a load is an indication but not an accurate measure of hysteresis loss. Exact evaluation of hysteresis loss by thermal means would require a knowledge of (*a*) the thermal capacitance of the test materials, (*b*) the thermal conductivity of the materials, (*c*) the distribution of heat losses from the surfaces of the test specimen by radiation, conduction and convection, and (*d*) the mathematical relationship for heat flow through a test specimen whose configuration and instantaneous temperatures are changing at the frequency of vibration. A solution of the problem does not seem likely, even assuming that painstaking research on one compound or one series of compounds might lead to a basis for limited calculation.

For a given class of compounds, the test is significant as an indication of the tendency to develop heat under severe conditions. Its particular advantage over other tests for hysteresis is that the element of fatigue and operation at elevated temperatures resulting from energy absorption are brought into play. Since these factors are important in the operation of automobile tires and belting, the field of maximum usefulness would seem to be apparent. Yet with the increasing use of rubber springs, particularly where damping action is required, fatigue tests of this type should find increasing use for final confirmation of spring designs. It should also be apparent that tests may be made in shear in the same type of apparatus by using a shear type of test specimen patterned after simple types of commercial shear mountings.

Hardness.—By convenience attained by no other test and by long usage, hardness measurements have become firmly established. Rubber is virtually incompressible, although its elastic compliance to irregular surfaces is appreciable. Its compliance in this sense serves as the basis for the familiar indentation tests. In general, the recognized hardness tests, operating on a flat surface, employ a washer face held against the composition to define the area of the test. The penetrating pin is brought against the exposed surface of the composition through the hole in the washer. Two methods of running the test are common at the present time. In the first and more popular method pressure of the rubber against the pin is resisted by a spring. Readings on an arbitrary scale are proportional to the force exerted on the pin by the rubber. Also, since the spring obeys Hooke's law, the readings are proportional to the linear travel of the pin from the extended or zero position. In the second method, a constant force is applied to the pin and the linear penetration into the surface of the vulcanizate is measured. Both methods depend upon arbitrarily determined factors including the diameter of the washer, the thickness of the test specimen, the length and shape of the pin, the pressure on the washer, for the spring-actuated type the spring constant and initial setting, and for the weight-actuated type the size of the weight. Inaccuracies in hardness measurements have long been tolerated, but this situation must be improved. It is reassuring that the Society's Committee D-11 on Rubber Products is giving this matter intensive consideration at the present time and that a pronounced improvement may be expected.

Hardness measurements are an indication of modulus of elasticity of vulcanizates, but not specifically a measure of modulus. As the pin of the hardness tester presses into the surface of the vulcanizate, material directly under the pin is subjected to compression at the same time that lateral displacement of some of the material produces stress in shear. Assuming an interrelation between moduli of elasticity in compression and shear, the penetration of the pin is dependent primarily upon the modulus of elasticity of the vulcanizate in shear, but it is modified by any concurrent plastic tendencies. Since the hardness figure for a given vulcanizate depends upon a single test condition, it can be expected to correlate with no more than a single value of the shear modulus. To the extent that different vulcanizates have differently shaped stress-strain curves we may expect deviation of hardness figures from exact correspondence to shear modulus.

Having experienced satisfaction with one composition having a definite hardness, how far can one go toward expecting that another composition of the same hardness will serve as well? This depends largely upon how important modulus of elasticity is in comparison with other properties. If modulus is of prime importance, the hardness measurement may suffice; if of secondary importance, hardness is also of secondary importance.

SUMMARY

Some tests are intended to measure not one but a group of physical properties associated by a particular application. The tests conceivably throw considerable light upon the usefulness of rubber in that application and lead to marked improvements of performance by changes in compounds and mechanical design. When such a test performs preeminently well for that service, there is danger that if the connection is not clearly conceived too much may be expected from it with respect to some other service. Interpretation of results is usually complicated by changes occurring in the test specimen during the test and by dependence upon attending conditions, notably the temperature. The complicated nature of even to reduce tests to their minimum essentials and to exercise the utmost judgment in applying laboratory data to the the most simple tests presents a challenge to the investigator solution of practical problems.

Magnetic Analysis Applied to the Inspection of Bar Stock and Pipe*

By Theodor Zuschlag[1]

SYNOPSIS

The increasing application of magnetic analysis to the testing of all types of steel of uniform cross-section has prompted the preparation of this paper, which aims:

1. To point out the highlights in the historical development of the magnetic methods for the inspection of bar stock and pipe.
2. To describe the apparatus now predominantly used for this purpose.
3. To report certain technical facts related to those inspections.
4. To discuss some practical problems encountered in this connection.

THE demand for better quality of steel has resulted in a call for reliable, sensitive, economic and, preferably, nondestructive methods of inspection. As far as bar stock and pipe are concerned, the method which meets most of these requirements is magnetic analysis.

The possibility of using magnetic measurements for the investigation of the nonmagnetic properties of metallic conductors has long been recognized. The first practical application of this principle, probably, was made in 1868 when S. M. Saxby[2] used a magnetic compass to detect flaws in iron castings. Eight years later, Charles M. Ryder obtained a patent[3] for an "improvement in devices for testing carbonization of metals," a forerunner of the Swedish carbometer. In 1877, Anaxamander Herring patented[4] an "improvement in modes of detecting defects in railroad rails," while two years later, he patented[5] "a method of ascertaining the density or tensile strength of iron and steel."

During the same year, D. E. Hughes published his famous paper[6] about a new induction balance. This instrument, originally designed for the investigation of the conductivity of metallic articles by means of alternating current induction effects, proved to be one of the major contributions to the art of magnetic testing. One year later, in 1880, J. Joubert[7] published a paper about a new wave form analyzing apparatus using a rotating disk and point contact measurements, a principle which, in an electronic modification, is still employed in magnetic inspection equipments.

The references cited so far establish the fact that even at this early date attempts were made to utilize magnetic and electric measurements for practical inspection purposes. The detection of flaws as well as the analysis of composition, structure, hardness and mechanical condition are clearly mentioned.

The next important forward step, as far as industrial applications are concerned, was made in 1902 by A. B. Goldschmidt[8] who proposed an improved induction balance for the comparison of a known and an unknown steel specimen. Other arrangements of this type subsequently have been proposed by Van Lonkhuysen,[9] Pozzo and Colonnetti,[10] the Erda Institute,[11] C. Kinsley[12], and H. C. Knerr and C. Farrow.[13]

D. E. Hughes, in his induction balance, used as indicators both galvanometers and telephones. Since then, these two types of detectors always have been most popular for such investigations. The first attempt to utilize an oscillograph for this purpose was made by E. Madelung[14] who, in 1907, investigated the effect of an iron core upon the wave form of an induced electromotive force by means of a cathode-ray oscillograph. This interesting investigation, unfortunately, was not followed up and it was not until 1927 that C. Kinsley[12] rediscovered the usefulness of the oscillograph for this particular testing purpose.

The beginning of commercial magnetic analysis may be traced from the development of the defectoscope by Burrows[15] and the introduction of the so-called leakage method of detection. This arrangement was particularly useful for the detection of flaws and its principle is still utilized in modern equipments. Burrows and his coworkers preferred the use of direct current for magnetic investigation; yet Hughes, as early as 1879, reported that he was able to distinguish soft and hard steel specimens by the different sounds they produced in the telephone detector of his alternating-current induction balance. The question of direct-current testing *versus* alternating-current testing has never been decided finally and still is a controversial subject. The preferred frequency for alternating current testing is commercial line frequency, but lower and higher frequencies have been utilized with advantage by many investigators.

Simultaneous energization by means of both alternating and direct current was first proposed in the previously mentioned Erda patent.[11] Later Knerr and Farrow[13] advanced

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[1] Chief Engineer, Magnetic Analysis Corp., Long Island City, N. Y.

[2] S. M. Saxby, "Magnetic Testing of Iron," *Engineering*, Vol. 5, p. 297 (1868).

[3] Charles M. Ryder, "Improvement in Devices for Testing Carbonization of Metals," U. S. Patent 185,647 (1876).

[4] Anaxamander Herring, "Improvement in Modes of Detecting Defects in Rails and So Forth," U. S. Patent 189,858 (1877).

[5] Anaxamander Herring, "Improvement in Ascertaining the Density and Tensile Strength of Iron and Steel," U. S. Patent 213,197 (1879).

[6] D. E. Hughes, "On an Induction Balance and Research Therewith," *Philosophical Magazine*, Series 5, Vol. 8, p. 50 (1879).

[7] J. Joubert, "Sur les courants alternatifs," *Journal de Physics*, Vol. 9, p. 297 (1880).

[8] A. B. Goldschmidt, "Nullmethode für magnetische Messungen," *Elektrotechnische Zeitschrift*, Vol. 23, p. 314 (1902).

[9] Van Lonkhuysen, "Eine neue Messanordnung zur Prüfung von Eisenblechen," *Elektrotechnische Zeitschrift*, Vol. 32, p. 1131 (1911).

[10] A. Pozzo and G. Collonnetti, "Apparatus for Testing Iron," U. S. Patent 1,335,985 (1919).

[11] Erda Institute, "Verfahren zum Prüfen von magnetischen Material," Austrian Patent 98,935 (1924).

[12] C. Kinsley, "Method and Apparatus for Magnetic Testing," U. S. Patent 1,813,746 (1931).

[13] H. C. Knerr and C. Farrow, Method and Apparatus for Testing Metal Articles, U. S. Patent 2,065,379 (1936).

[14] E. Madelung, "Neue Verwendungsarten der Braunschan Roehre," *Physikalische Zeitschrift*, Jahrgg 8, No. 3, p. 72 (1907).

[15] C. W. Burrows, "Method and Apparatus for Testing Magnetizable Objects by Magnetic Leakage," U. S. Patent 1,322,405 (1919).

the idea of saturating magnetic material by means of a heavy direct current magnetization in order to make such material substantially nonmagnetic for inspection purposes.

Early investigators had found it preferable to use test methods based upon a relative comparison of magnetic and electric properties rather than upon measurements of absolute values. A specimen known to possess the desired mechanical and metallurgical properties and the necessary freedom of flaws was used as the standard of comparison, and all other unknown specimens were compared against this standard. During recent years the use of these direct comparison methods has declined in favor of so-called artificial electric standard methods. One practical reason for this development was the heating up of the standard, particularly when exposed to strong alternating fields. This condition called for special cooling provisions not necessary with electric standard combinations. Arrangements of this type were proposed by de Forest[16] and Kinsley.[17] In these methods a standard of known properties is balanced in a bridge or compensating network with regard to its magnetic and electric characteristics. Retaining the thus determined setting or compensation of the network, the standard then is replaced by the unknown specimen and the resultant balance noted.

The two major problems in most electric standard circuits concern phase and harmonics. The phase problem involves the installation of an efficient phase-shifting device, as well as the selection of a satisfactory operating phase for the balance indicator. If galvanometers are used for this purpose, consistent and reliable inspection of the mechanical properties under investigation depends upon the selection of the right indicator control phase. Similar considerations prevail with respect to other types of indicators using various mechanical or electronic principles (F. Fischer,[18] T. Zuschlag[19] and W. Thal[20]). In this connection, the Thal Ferrometer deserves special mention. This instrument features a vibrating rectifier type indicator which, together with suitable measuring circuits, permits a variety of important and valuable magnetic measurements and wave analyses difficult to duplicate by other means.

The harmonics problem normally can be solved without difficulty by the use of standard wave filters. The policy generally followed in this respect calls for the elimination of all harmonics, but some investigators prefer a more complete analysis of the resultant harmonics, as described by B. M. Smith[21] and C. Kinsley.[22]

NEW APPARATUS FOR THE INSPECTION OF BAR STOCK AND PIPE

During the past few years, many interesting developments in magnetic testing instruments have taken place that have not been described in the technical literature. One type of equipment, manufactured and leased by the Magnetic Analysis Corp. of Long Island City, permits a continuous inspection of bar stock and pipe from $\frac{1}{4}$ to $3\frac{1}{2}$ in. in outside diameter for freedom of flaws and uniformity of analysis, structure, heat treatment, cold working, hardness, and dimension. This instrument incorporates a combination of several test methods, applied simultaneously and found to be particularly suited for bar stock and pipe investigation.

The complete equipment, shown in Fig. 1, comprises a test coil assembly, an indicator and control cabinet, a stabilizing voltage regulator unit, an accessory cabinet, an elevating table, and a feeding mechanism.

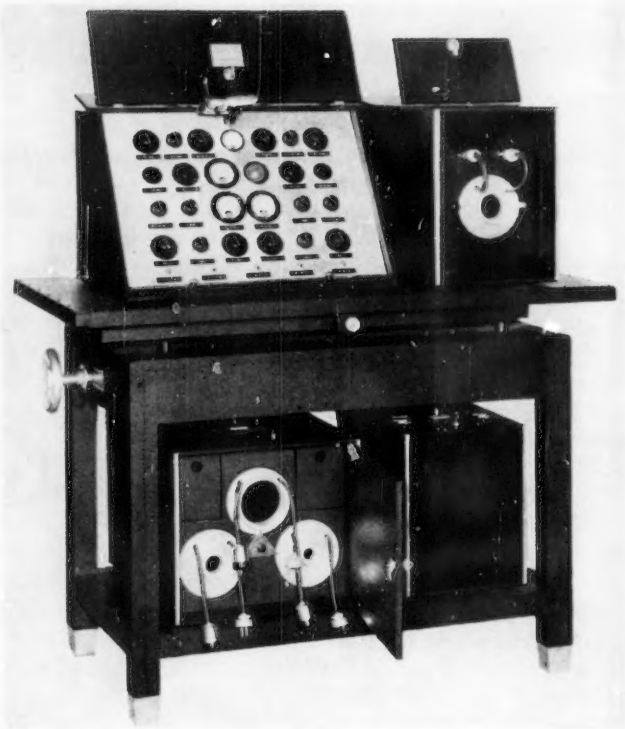

FIG. 1

The test coil assembly (upper right of Fig. 1) consists of a heavy primary coil and four exchangeable secondary coils. The material to be inspected is passed through a secondary coil, coaxially located within the primary coil, and is energized by alternating current of line frequency. Each secondary coil contains a number of secondary windings which serve as "pickup and detector means" for the various test and control circuits.

The indicator cabinet (upper left of Fig. 1) contains the controls and the indicators for the various test methods, as well as several vacuum tube circuits for measuring and amplifying purposes.

The voltage regulator unit (lower shelf right, Fig. 1) is an electronically stabilized power supply for the indicator unit and in most installations must be supplemented by a larger size voltage regulator for the primary coil current supply. The purpose of both devices is the elimination of all voltage surges which might be encountered in the line supply of a steel mill.

The accessory cabinet (lower shelf left, Fig. 1) is the

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[16] A. V. de Forest, "A New Method of Magnetic Inspection," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 611 (1923).

[17] C. Kinsley, "Steel Structures Identified and Flaws Located by Means of Balancing Wave Tests," *Proceedings*, Am. Soc. Testing Mats., Vol. 38, Part II, p. 36 (1938).

[18] F. Fischer, "Schaltanordnung," German Patent 579,838 (1933).

[19] T. Zuschlag, "Electrical Analysis Method," U. S. Patent 2,079,645 and "Magnetic Analysis," U. S. Patent 2,098,991 (1937).

[20] W. Thal, "Schwing-gleichrichter und Eisenuntersuchungen," *Zeitschrift für technische Physik*, Vol. 15 (1934).

[21] B. M. Smith, "Some Recent Developments in Electromagnetic Inspection and Test Equipments," *General Electric Review*, Vol. 36, p. 368 (1933).

[22] C. Kinsley, "Magnetic Testing of Masses," U. S. Patent 1,910,770 (1930).

storage place for the secondary coils not in use, as well as of other auxiliary items.

The elevating table, in connection with the feeding mechanism, not shown in this picture, plays an important part in continuous production testing. This table permits an easy raising and lowering of the test coil assembly in order to line it up for the inspection of bars of different diameters.

The coil assembly and the indicator contain four different test and control circuits. Three of these circuits relate to individual and independent methods of inspection, operating simultaneously, while the fourth controls a relay mechanism for the automatic protection of the indicators of the three test methods.

Most important of the three test methods is the flaw detector circuit[23], which, theoretically, is based upon Burrows' leakage method of magnetic inspection. Practically, it depends upon the action of special detector coils in connection with a compensating network and a high gain amplifier. The output of the amplifier is measured by means of a microammeter and controls the flashing of a neon light made necessary by the relatively high speed of inspection. Employing an average speed of about 120 ft. per min., short defects may not cause impulses sufficient for a noticeable deflection of the microammeter, although they are strong enough to produce a distinctive flash of the neon light.

The special detector coils consist of two pairs of concentric windings disposed within each other and connected in series opposition with each other. Such a coil combination possesses peculiar properties. Being practically noninductive, it exercises a definite selective action with regard to magnetic variations of different origin. In many materials it emphasizes indications pointing to flaws and suppresses indications caused by unimportant strain variations. To produce this very desirable condition, special care must be taken in winding these coils. Without such precaution, disappointing results are almost certain, while correctly designed coils not only possess an inherently high degree of sensitivity, but also permit a certain amount of variation of selectivity best comparable with a tuning of the flaw detector circuit to different types of variations.

The basic principle of this method relates to a comparison of one section of the test bar with another section of the same bar. This principle, while making possible an extremely high sensitivity, on the other hand, limits this method to indicating the beginning and end of a defect only. For this reason, continuous seams even of considerable depth sometimes are not detectable with this circuit. The high sensitivity of the flaw detector circuit requires that the test bars move through the test coil with constant speed. Variations in speed produce deflections which in turn may lead to misinterpretations as to the cause of such deflections.

Supplementing the flaw detector circuit are two electric standard circuits of the wave analyzer type. Their principle of operation goes back to Joubert's point contact method,[7] but the actual design used is based upon electronic rather than mechanical point contact means.[24] Two electromotive force curves induced in separate detector windings are investigated, with regard to variations of amplitude, at certain arbitrarily fixed phase points. The investigation is carried out by applying the induced electromotive forces to independent vacuum tube circuits normally nonconductive, but temporarily conductive during the passing of the selected phase point. A modification, now preferably used, was proposed by T. C. Hana.[25]

The amplitudes of the electromotive forces at the respective phase points are comparable with direct current impulses of short duration. These impulses, for measuring purposes, are neutralized by other impulses of the same amplitude but of opposite sign. Such an arrangement permits a very high sensitivity with regard to slight amplitude variations. This sensitivity, of course, can be utilized only as long as the voltages energizing the primary coil and the indicator remain constant, which requirement explains the need for the voltage regulators mentioned before.

The two point methods are employed for the detection of flaws as well as the investigation of analysis variations. As far as the investigation of flaws is concerned, the sensitivity of the point methods, at present, is lower than that of the flaw detector circuit. Nevertheless, these methods possess the advantage that they outline the full length of defects, including continuous seams, if these defects produce an indication. Another advantage of the point methods is their high degree of selectivity with regard to the investigation of certain specific properties. This desirable condition is brought about by the possibility of arbitrarily selecting any phase value as the operating point of these methods. As this method is not intended for the detection of short flaws, no speed indicator, such as the neon light used in the flaw detector circuit, is provided. All indications, at present, are presented by

[23] T. Zuschlag, "Detection of Flaws in Magnetizable Bodies," U. S. Patent 2,102,452 (1937).
[24] T. Zuschlag, "Electrical Measurement," U. S. Patent 2,140,662 (1938).
[25] T. C. Hana, "Magnetic Testing," U. S. Patent 2,152,690 (1939).

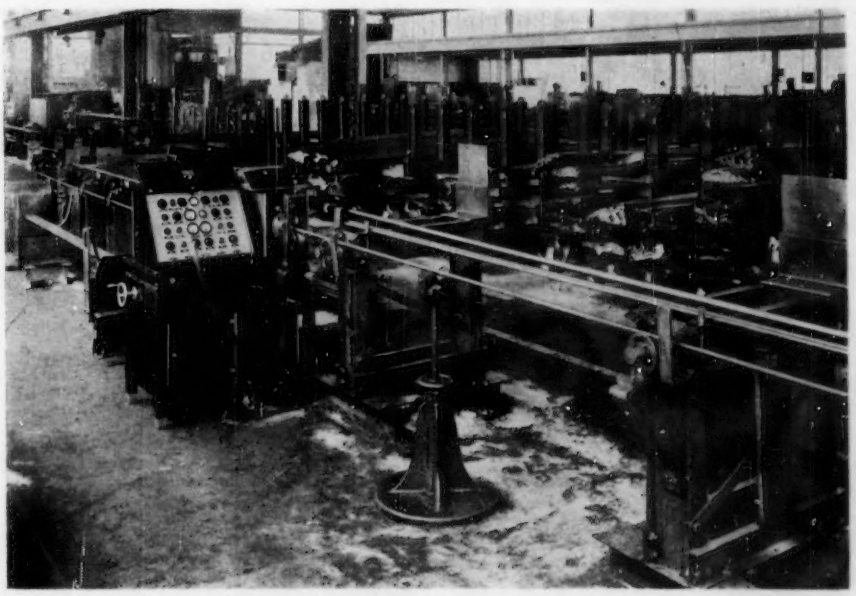

FIG. 2

means of two zero-center meters, one for each method combination.

Generally speaking, two major operating regions may be distinguished with respect to the investigation of the induced electromotive force curves. One region comprises the measurements of maximum electromotive force values and the other the measurements of minimum or zero electromotive force values. Considering the fact that the induced electromotive forces, as far as the magnetizing force is concerned, are lagging 90 deg. in phase, it is apparent that maximum electromotive force values correspond to minimum or zero field values, while minimum electromotive force values relate to the maximum field values. This relationship explains why many investigations based upon the inspection of maximum electromotive force amplitudes may be correlated with observations related to coercive force points measurements. Particularly is this true of investigations covering variations in hardness, structure, analysis, and so on. On the other hand, minimum electromotive force investigations generally do not yield much magnetic information, but seem to be most efficient with respect to investigations of conductivity changes or eddy current distribution.

The incorporation of two independently operating point methods into the magnetic tester makes it possible to obtain, simultaneously, information at least partially differentiated as to magnetic and electric properties. In routine inspection, one of the point methods is, preferably, operated at maximum electromotive force amplitude while the other point method is set to investigate variations in minimum electromotive force values.

One difficulty occasionally encountered with this method relates to the fact that the selection of the right operating phase point is not always an obvious matter and may require preliminary experimentation by the operator of the equipment. On the other hand, an experienced operator is enabled to maintain a standard of inspection which can only be duplicated by a combined and careful physical, chemical, and visual inspection.

The fourth circuit mentioned is the indicator control combination.[26] This arrangement relates to an electronic control mechanism which protects the test method indicators against overloading. The difference in meter deflection with and without material passing through the test coil is so great that it would endanger the delicate pointers of the indicators if no protective switching was provided. The installation of accurately timed and automatically operating relays has definitely eliminated this danger.

The actual operation of the tester may be visualized with the help of Fig. 2 showing a typical installation in an Eastern steel mill. The operator first sees that a correctly matched secondary is installed. The elevating table then is raised or lowered until the bars, placed upon the straight rollers in front of the rack, pass freely through the secondary. The pressure wheels of the feed rollers in front, as well as in back of the coil cabinet (not visible), are adjusted, the right speed drive is selected, and the feed roller motor started.

One of the bars is selected as the standard of comparison, preferably after a thorough check as to correct analysis, dimension, heat treatment, and freedom from flaws. Passing the bar through the test coil, the three test circuits are individually and successively compensated. The passage and compensation are repeated until all indicators show zero deflection for the desired degree of sensitivity and selectivity. The standard bar used in setting up the equipment is retained for occasional checks, at least until the inspection of the heat under investigation has been completed.

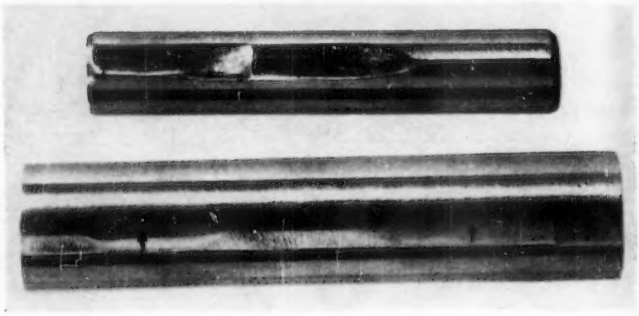

FIG. 3

The operator then passes one bar after another through the coil, watching the resultant meter deflections, as well as neon light flashes. Each inspected bar, after its passage through the test coil, is selectively thrown off to either side of the rollers (visible behind the indicator) by means of the throw-off lever located in front of the elevating table.

NATURE OF EXAMINATION

Among the properties for which magnetic inspection is made are chemical analysis, structure, uniformity of heat treatment and cold working, hardness, dimensions, mechanical strain, and freedom from flaws. Most important, from an inspection point of view, is the freedom from flaws, and it is for this purpose that magnetic analysis equipments are primarily employed at present.

Using alternating current, the depth of penetration of these methods is limited. This fact, in general, precludes the possibility of locating internal defects such as pipes and restricts magnetic inspection to the detection of surface

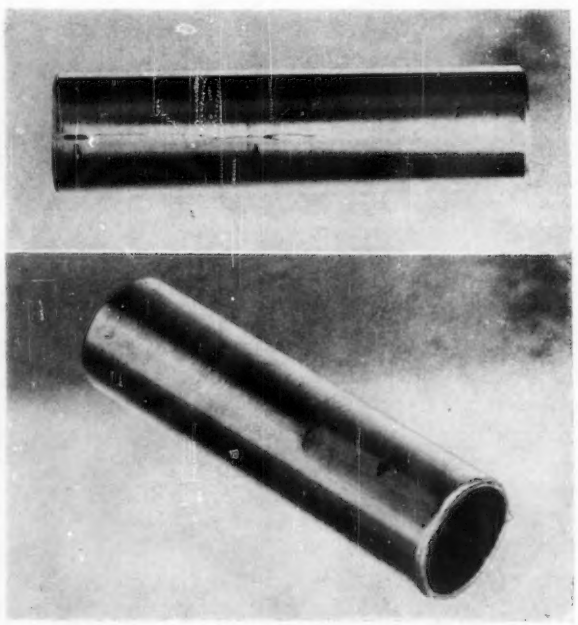

FIG. 4

[26] T. Zuschlag, "Magnetic Analysis," U. S. Patent 2,102,451 (1937).

flaws. Referring to Fig. 3, two short sections of round bars show a type of intermittent seams filed after detection for better visualization. Figure 4 illustrates two specimens of seamless tubing, containing inside and outside seams, while Fig. 5 shows a subsurface crack in a round bar starting below the surface and extending to the center. The last flaw, undoubtedly, could not have been revealed by visual inspection.

The type of defect which may be detected magnetically varies with all the properties that cause any change in magnetic conditions. For this reason, it is impossible to state offhand what depth of seam or crack may be found without taking into consideration the chemical composition, physical condition, and metallurgical history of the test specimen.

The types of steel particularly suited for magnetic inspection are machine-straightened, hot-rolled and cold-drawn bar stock and several types of pipe and tubing, including butt welded - cold drawn, electric welded and seamless. Bar stock (all shapes) is inspected for variations in carbon, manganese, sulfur and alloys; mechanical defects, such as cracks, seams and deep slivers; structure, such as segregations where these are characteristic of the blow or ingot from which the bars were rolled; and uniformity of heat treatment. Pipe and tubing, depending on the method of fabrication, is inspected for analysis variations, uniformity of heat treatment, weak or open welds, and uniformity of hardness and tensile strength.

The following grades of steel have been inspected by magnetic equipment for seams, cracks, slivers, and chemical analysis:

S.A.E. 1010—1015—X1015—1020—X1020
1035—1040—X1045
1112—X1112—1120—X1120
X1314—1315—1335—X1335—X1350
T1335—T1350
2315—2320—2330—2512
3115—3120—3135—3140—3250
4140—4145—4615—4620
5115—6140—9260

The following steels have been inspected for heat treatment, structure, and hardness:

S.A.E. 1040—1045—X1045
T1350
4140—4145
6140

It is interesting to note that as much as 20 tons of 1-in. material have been inspected by one operator within one 8-hr. shift. While this amount is somewhat higher than the average, 10 tons are easily maintained under normal conditions. The total tonnage per man-hour shift depends upon the type of material; the speed of testing; the quality of the mechanical setup, including provisions for handling the material; the standard of inspection; and the human element in the person of the operator.

Solid bars obviously mean higher tonnage figure than light-wall tubing, while bars of large-size diameter cannot be tested with the same speed as bars or tubes of small diameters. The quality of the mechanical setup, including efficient handling provisions, is an important factor which is easily underrated, yet, nevertheless, may be responsible for inferior inspection results as well as low tonnage and high cost figures. A high standard of inspection may force a slower speed of testing to avoid passing certain types of defects. Finally, the human element or, more specifically, the ability of the operator, cannot be ignored. The operator need not possess any technical training, nor be a skilled worker, but reliability, a certain amount of natural skill, and an open mind are desirable prerequisites.

Commercial magnetic testing by the Magnetic Analysis Corp. was launched about 8 yr. ago. Starting very modestly in 1931, the tonnages reported during the first quarter of 1939 have risen to almost sixty times the amount reported for the same period in 1933.

PRACTICAL PROBLEMS

Considering the various points discussed so far, it is obvious that a magnetic inspection equipment must satisfy quite a number of divergent requirements, the most important of these being reliability, selective sensitivity, and simplicity.

Reliability not only means consistency as far as the test results are concerned, but also ruggedness and ability of the equipment to stand up under continuous operation. Consistency of performance, at present, depends upon the steel to be tested rather than upon methods and apparatus, while the ability to "take it" is a question of quality of material as well as of servicing. On the other hand, even the highest quality equipment, incorporating as it does such a variety of complex items as amplifier tubes, sensitive meters, electromechanical relays, precision resistances, and potentiometers, cannot be expected to operate indefinitely without some kind of failure, which requires frequent and expert supervision.

Selective sensitivity may be defined as the ability to emphasize weak but important indications and to suppress strong yet unimportant or otherwise undesired variations. With regard to selectivity, this characteristic, within certain limits, is realized through the action of the special coils of the flaw detector circuit, and, as far as the point method is concerned, through the possibility of selecting operating phase points, the amplitudes of which, primarily, are affected by desired variations. Sensitivity without selectivity, generally, presents no problem and, in modern apparatus, is easily accomplished with the help of amplifying tubes and circuits.

The desire for simplicity has been responsible for many improvements in design and operation. In this connection, it may be mentioned that simplicity of operation is not

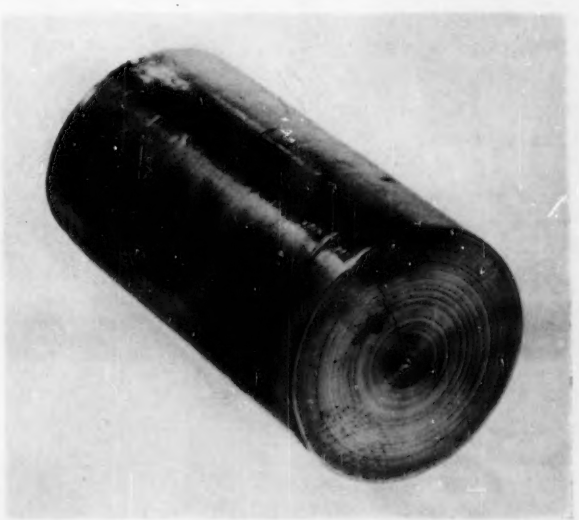

FIG. 5

synonymous with simplicity of design. In fact, it is possible to build magnetic testing equipment featuring extremely simple, even fully automatic operation, but the design of these instruments might be so complicated as to preclude their economic justification.

During the year 1916, Burrows[27] published a summary on the correlation of magnetic and mechanical properties of magnetic material in which he stated that two specimens of identical composition, dimension and magnetic properties should possess the same mechanical characteristic and that any treatment which alters the mechanical properties of the specimens also changes their magnetic properties. These principles, in general, have been checked and proven, but, they cannot always be reversed. Seemingly, no direct relation exists between magnetic and mechanical properties, even for the same material. All such relations must be considered as indirect and substantially based on secondary effects only. This fact, undoubtedly, constitutes the major difficulty in the practical application of magnetic analysis.

The least important of the properties measured by magnetic analysis, from a commercial point of view, are mechanical strains and stresses. Unfortunately, the same is not true as far as the effect of these strains upon the magnetic properties of magnetic materials is concerned. It is not unusual that slight variations in strain cause changes in magnetic properties out of all proportion compared with the effect upon other mechanical properties. On the other hand, any change in chemical analysis, structure, heat treatment, cold working, hardness, as well as physical condition and dimension, may vary the distribution of mechanical strain considerably, thus affecting, in turn, the magnetic properties. In last analysis, it is this relationship that is investigated by most magnetic inspection methods. From this point of view, the success or failure of these methods, ultimately, is dependent upon the existence or nonexistence of such secondary strain effect or strain variations rather than upon any direct relationship with the primary cause of these strain conditions.

Magnetic analysis, therefore, is not a direct method of investigating mechanical properties, but an indirect method only, based upon the fact that most, if not all, physical, chemical, and metallurgical changes cause variations in strains and stresses. To show a magnetic variation a test specimen must possess a strain condition different from that of the original standard. If this condition is not present, then the equipment may pass the test specimen as satisfactory despite the fact that the specimen is of different analysis or contains a serious flaw. This theory explains many disappointments encountered with magnetic analysis. Fortunately, however, bars of different analysis or containing flaws generally possess sufficient variations in strain to insure their successful elimination by magnetic analysis inspection methods.

The deficiency just mentioned has been and still is the main practical drawback of magnetic inspection. On the other hand, investigations now carried on indicate the possibility of overcoming at least part of these difficulties by increasing the selective sensitivity of the equipments.

In conclusion, it can be definitely stated that magnetic inspection has made considerable progress during the past few years. Even if the relationship between magnetic and mechanical properties is not as direct and simple as was formerly hoped for, the results obtained with modern equipments are remarkable and justify confidence in the further development of magnetic analysis.

[27] C. W. Burrows, "Correlation of the Magnetic and Mechanical Properties of Steel," *Scientific Paper 272*, Nat. Bureau Standards, Vol. 13, p. 173 (1916).

Special Committee for Testing of Textile Finishes

EARLY in 1938 the officers of A.S.T.M. Committee D-13 on Textile Materials were asked whether the committee would be interested in sponsoring research on methods for testing of textile finishes. A number of the prominent companies in the textile and related industries, who were approached by the officers of the committee, expressed an interest in the proposed research program and willingness to give it financial support. A Steering Committee organized under the direction of G. E. Hopkins consisting of representatives of these companies undertook to organize a research program and to collect an adequate research fund for carrying out this program.

As a result of the activities of the Steering Committee, the Special Committee for Testing of Textile Finishes was organized at a meeting held at the Chemists' Club in New York City on January 26, 1939. The membership of the Special Committee is composed of those companies which have subscribed to its research fund with Professor Ball, Chairman of Committee D-13, and two Advisory Members, W. D. Appel, National Bureau of Standards, and K. H. Barnard, Chairman of the American Association of Textile Chemists and Colorists Committee on Crease Resistance and Permanency of Finish on Fabrics. The activities of the committee will be directed by a Directing Committee of three members, L. B. Arnold, Jr., Chairman, Professor H. J. Ball and Miss Elizabeth Weirick.

The present subscribers to the research fund are:

American Viscose Corp.	Hercules Powder Co.
Cranston Print Works Co.	National Oil Products Co., Inc.
E. I. du Pont de Nemours & Co., Inc.	Sandoz Chemical Works, Inc.
Geigy Company, Inc.	Scholler Brothers, Inc.
The Hart Products Corp.	Sears, Roebuck & Co.

Dr. E. C. Dreby, who recently completed his graduate studies at Yale University, has been appointed research associate for the Special Committee and will assume his duties shortly at the National Bureau of Standards, where the research program will be carried out.

The object of the research program of the Special Committee for Testing of Textile Finishes is to develop physical testing methods for the evaluation of various types of textile finishes. The principal interest is in the development of a practical, effective method for evaluating the "handle" of textile fabrics. The "handle" of a fabric is the textile term to indicate the way it feels when handled. The present method of evaluating this property is simply to feel the fabric and judge its feel in comparison with the feel of other fabrics with similar finishes. This requires an individual of great experience and is at best highly subjective. An effective testing method would be of great value to all who have need to evaluate the "handle" of fabrics. Other types of finishes on which research will be carried out are crease-proofed finishes, slip-proofed finishes, shrink-proofed finishes, and flame-proofed finishes. Considerable research has already been done on the development of test methods for these latter types of finishes, but it is felt that there is still room for improvement.

Inter-Society Color Council Active

SINCE the organization of the Inter-Society Color Council a few years ago, the Society has continued its support as a member body and has been represented by four delegates: M. Rea Paul, National Lead Co.; A. W. Kenney, E. I. du Pont de Nemours & Co., Inc.; H. M. Hancock, The Atlantic Refining Co.; and W. M. Scott, Gustavus J. Esselen, Inc. Each year a report is submitted to the Council on behalf of the member bodies and the Society's representatives also report on the work of the Council to A.S.T.M. Since quite a number of members of the Society are concerned with color, it is believed the material which follows, abstracted from the report to the Society, will be of interest.

During the past year, the American Ceramic Society has become affiliated with the Inter-Society Council as its tenth member-body. The gradual importance which the council is assuming in matters pertaining to the development of knowledge with regard to color, and the dissemination of that knowledge, has added many new individual memberships.

In the following, some of the successful projects are mentioned as evidence of how the council works, and the type of projects on which its committees are engaged.

What the Council Has Done:

(1) Color Names: The U. S. Pharmacopoeial Revision Committee, in 1931, requested the council to develop "a means for designating colors in the U. S. Pharmacopoeia, in the National Formulary, and in general pharmaceutical literature; such designation to be sufficiently standardized as to be acceptable to science, sufficiently broad to be appreciated and usable by science, art, and industry, and sufficiently commonplace to be understood, at least in a general way, by the whole public." They required not only a system of color names but also a means of selecting a system of working standards for its application which would not open the committee to the criticism of favoring one private concern over another. By 1932 the general plan of a system of color names had been worked out in the council. Further details were added, and in 1938 a review of the final details was approved. This plan is now being put into effect, and it is expected that a final revision of the system will be approved at the 1939 annual meeting. The tentative system is already being used by the U. S. Pharmacopoeial Revision Committee. The council thus obtained for one of its member bodies the advice of the color experts of two other member bodies (the Optical Society of America and the American Psychological Association); it obtained for this member body the cooperation of the National Bureau of Standards; and the council served as an authoritative source of information not swayed by commercial considerations for deciding which of the various competing systems of material color standards was best suited to derivation of the color names.

(2) Designation of Gelatins for Stage Illumination: At the request of a member body (the Illuminating Engineering Society), there has been worked out a method which seems to be adequate and also simple and practical. This method will be submitted to the council delegates for approval by letter ballot this fall. In this case, the council gave its joint advice at two annual meetings and secured the interest and services of a delegate from another member body (the Optical Society of America).

(3) Who's Who in Color: A reference list of about 250 persons who are recognized as authorities in their particular branches of color work (scientific, technical, educational, and industrial) has been compiled and published.

(4) Survey of Color Terms: This survey has been completed by five of the nine member bodies; surveys by three of the remaining member bodies are expected to be completed during this year. The survey has revealed many color terms generally known only within one member body and many instances in which the same term is used in different senses in different member bodies. A good beginning has been made for a Dictionary of Color Terms.

(5) Survey of Color Tests and Specifications: This survey has been completed by three of the nine member bodies; surveys by the remaining member bodies, except the American Psychological Association, are in progress. There are no color tests or specifications recognized in the A. P. A.

(6) Review of the Spacing of the Munsell Colors: The Munsell Book of Color is supposed to show samples of constant hue, samples of constant lightness (value), and samples of constant saturation (chroma); and the members of the various series showing changes only in one of these three attributes are supposed to be separated by color intervals which are visually equal. It was suggested in the 1937 council meeting by individual members of the council and by some of the delegates from the Optical Society of America that the samples of the Munsell Book of Color be subjected to careful study to determine how well they conform to the intent of the book with the ultimate purpose of producing, if necessary, a book which complies more accurately with that intent. It developed from the efforts of these delegates to obtain official sponsorship for this problem that the Optical Society was sufficiently concerned in the solution of this problem to undertake it independently. Accordingly a special subcommittee of the O. S. A. Committee on Colorimetry was appointed for this study which is now nearing completion. Graphs showing preliminary results of this study are already in use in the Color Laboratory of the Bureau of Agricultural Economics, U. S. Department of Agriculture. The accomplishment of the council was to stimulate the study of color within one of its member bodies and to obtain for it the active cooperation of delegates from another member body (the American Psychological Association).

(7) Symposium on General Electric Recording Spectrophotometer: The afternoon session of the 7th Annual Meeting, February, 1938, was devoted to five related papers on this subject. These papers were published in the *Journal* of the Optical Society of America. In this case, the council is the means through which the members of the O. S. A. will obtain information on this timely and important instrument of color standardization.

Some Future Problems for the Council:

(1) Vitreous Color Standards: Already widely used for vitreous products themselves, such standards are becoming increasingly used for paints, textiles, and other materials which are of inferior permanence. A delegate from the Technical Association of the Pulp and Paper Industry mentioned the necessity of a primary reflection standard to supplant the present standard, magnesium oxide. Vitreous samples have been suggested as a possible solution. Most of the member bodies require information about the availability, permanence, color range, and cost of vitreous enamel samples for working standards of color.

(2) Uniform Color Tolerances: The substantial loss to industry from rejection of off-color material is too well-recognized to require supporting evidence and often the color tolerance is more strict than the use of the material justifies. The manufacturer would be only too glad to use larger tolerances, but the purchaser in many cases does not understand the necessary connection between size of color tolerance and cost per accepted unit. Any system of color tolerance agreed upon in advance between buyer and seller would be a real service to industry.

One of the delegates representing the American Society for Testing Materials stated that: "Attention should also be given to the question whether the subject of color tolerances can be handled in a way which is at once fundamental, and yet sufficiently simple to be applicable to commercial practice." If the council were to encourage a study of the methods of administering color tolerances, and once having found a practical method, to recognize certain definite color tolerances for certain definite typical uses, and to promote acceptance of these tolerances among consumer groups, the manufacturing interests represented on the council would benefit through increased profits, and the consumer interests, through lower prices.

A.S.T.M. members who may wish further information about the work of the Council can obtain this by writing the Council's secretary, Miss Dorothy Nickerson, Bureau of Agricultural Economics, Washington, D. C.

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Some Annual Meeting Impressions

As the Forty-second Annual Meeting of the Society was passing into history, a member mentioned to one of the staff how very much worth while he thought the meeting had been (and many similar comments were heard during the week). We like that expression, "worth while," as applied to the annual occasion when the members gather to accomplish the objectives for which they are banded together, and we are moved to point to at least three things that in our opinion made the recent meeting extremely worth while.

First, and perhaps most important, were the many opportunities to get together to discuss subjects of common interest. The entire week was filled with such opportunities, from the formal committee meetings and sessions to the informal but no less valuable personal associations. Full advantage was taken of these opportunities, for most meetings were well attended and everywhere one looked in the hotel lobbies and lounges groups of members were to be seen. We were particularly impressed with the keen desire to discuss the subjects scheduled as Round Table Discussions, such as, low-temperature properties of metals, accelerated weathering tests, freezing-and-thawing tests, and spectrochemical analysis—these meetings were among the best attended and most spirited of the entire week. We thought the groups of papers on paint testing, shear tests of soils, and water particularly interesting and enlivened by spirited discussion. In fact, it seemed that every one of the 1354 members and guests was taking the fullest possible advantage of the opportunity to meet with others and to exchange ideas on the many topics that appeared on the program—and probably a number that did not!

The second noteworthy thing about the meeting was its accomplishments in standardization. Since these are reported in detail elsewhere, we will merely say here that probably never before in the Society's history have its standards been so thoroughly reviewed and brought up to date as they were this year in anticipation of the new combined Book of Standards and Tentative Standards. About one-third of the contents of this book will bear the 1939 date. There was, too, a general "house cleaning" in some fields, withdrawing standards of long standing that had become more or less obsolete and in need of complete revision. The committees have been tremendously active and the worth-whileness of their work will be evident when the new volumes of standards are in the hands of our members.

The third item was the Exhibit of Testing Apparatus and Related Equipment—now firmly established as an integral technical feature biennially of A.S.T.M. meetings. On all sides we heard praise of the exhibitors for a splendid showing of testing devices and appliances, and we believe the exhibitors were rewarded for their efforts by attendance of many members who were seriously interested in the products on display. The committee exhibits and the photographic exhibition and competition added greatly to the general interest, and the thanks of the Society are extended to all who contributed to the undoubted success of these features.

A summation of these various impressions represents an appreciation of the intense interest being taken in the activities of the Society and what it proposes to accomplish; also the satisfaction that a member can derive from participation in the various features of an annual meeting.

TO OUR MEMBERS

To those of our members who have actively participated in our specification, methods of testing and research work, I extend congratulations on the character and volume of work done.

To those of our members whose support and use of standards and methods mean so much to our success, I ask your continued interest and a closer and more personal attention.

From all our members, I request constructive criticism. We want our service to be the best possible and our results to be the most useful.

I can assure you that our executive staff will be alert to all problems before it.

H. H. Morgan.

President

A Look at Some Society Problems

HAVING recorded elsewhere on this page some impressions of the annual meeting just passed, a look at some problems ahead of the Society may not be amiss. Indeed, the Executive Committee has been taking such a look during the past year and some of the things it has seen are mentioned in its annual report to the Society.

There is clearly a growing demand from industry for more knowledge of materials and for recording such knowledge in methods of tests and specifications. We see this on every side—in fields long occupied by the Society and in fields where new materials are being developed or old materials are being modified for new uses. The very fact that A.S.T.M. standards are so widely accepted as authoritative places a great responsibility upon the Society and its committees to see that its research activities are carried out thoroughly, that its standards are based upon the best and fullest knowledge obtainable, and that the greatest care is exercised to see that all sides of a question at issue are fully considered and all

parties having a proper interest have opportunity to be heard. To discharge this responsibility effectively and wisely is a task to which the Society must unceasingly dedicate itself.

This growing demand for knowledge and for standards requires steady expansion of the Society's activities, which brings us face to face with a most important problem: How can such expansion be financed most effectively and equitably? Consider first a few facts: During the past ten years the number of A.S.T.M. standards and tentative standards has increased 70 per cent; the number of committees has increased a fourth, and the number of members on all committees has increased a third. Our members today are receiving for the same dues at least 50 per cent more by way of standards, committee reports and technical papers than they did ten years ago. These increases, all a direct measure of Society activity, have taken place during a period of business depression which has held down the growth of membership, so that actually the income from membership dues today is somewhat less than it was ten years ago. However, increased sales of publications, which is one form of industry support of our work, has more than offset this loss, and has alone made possible the expansion that has taken place.

Here, then, is the essence of the problem: The activities and "output" of the Society have been growing more rapidly than its membership; is this a desirable condition? It has seemed to us that it is not, and that for sound and healthy development in the future the Society needs substantially to extend its membership and the income therefrom. For many reasons, a strong, virile *living* membership is essential to the continued success of work such as we do, and in this direction we must put forth our best efforts.

When we consider the new fields into which we are being drawn, it seems clear that an ever-widening base of membership is essential. We need more members from some of the newer industries in which we have begun to work, and experience indicates that such membership will grow as the work itself develops and becomes better known. Such things take time for accomplishment.

Important developments in standards for "consumer goods," so-called, are to be expected; there is a growing demand from consumer organizations for such standards—a demand already reflected in recent activities of our committees on textiles and detergents. To what extent the Society should engage in such work and how it should be financed, are problems that may need early consideration.

As a closing thought, the significance of Sustaining Membership in the Society is more clearly seen against this background of steady growth and development. It is essentially because of industry demand that our activities must expand, and Sustaining Membership provides opportunity for added industry support to help make such expansion possible.

C. L. W.

Largest Number of Actions on Standards Referred to Letter Ballot

By action of the Forty-second Annual Meeting, 225 recommendations from the standing committees affecting standards and tentative standards were approved for submission to letter ballot of the Society membership. These recommendations comprise 107 tentative standards proposed for adoption as standards and the adoption as standard of revisions proposed in 118 existing standards. As indicated elsewhere in this BULLETIN, this is the largest number of items ever acted upon at an annual meeting.

A complete list of the items to be voted upon appears in the letter ballot being sent in a separate mailing to the members. Detailed information concerning all matters referred to letter ballot is given in the committee reports issued in preprint form to the membership in advance of the meeting. The Summary of Proceedings accompanying the letter ballot contains a record of all actions taken at the annual meeting and also gives in full detail any changes in or additions to the standing committee recommendations as preprinted.

Several amendments to the By-laws of the Society were also referred to letter ballot. These are given in the report of the Executive Committee, to which reference should be made. Minor revisions are proposed in Articles II, IV and V. A new article VI is designed to provide specifically for the creation by the Executive Committee of the various committees of the Society—a function of the Executive Committee under the provision of Article IV vesting the general management of the Society in the Executive Committee. The proposed amendement of present Article VI, which will become Article VII, is designed to give effect to revised procedure governing the promulgation of standards which has been under discussion with Committees E-5 on Standing Committees and E-10 on Standards during the past year, and is fully described in the Executive Committee report.

The ballot will be canvassed on September 15 at which time all items receiving a favorable vote become effective.

More Sustaining Members

It is gratifying to report substantial increase in the number of Sustaining Members. Since the May BULLETIN was issued, the following seven companies have transferred from company to sustaining membership, bringing the total to 27—more than double the number (12) at the beginning of the year:

CONSOLIDATED EDISON CO. OF NEW YORK, INC., L. B. Bonnett, Engineer, Design and Planning, New York City.

ETHYL GASOLINE CORP., Thomas Midgley, Jr., Vice-President, Worthington, Ohio.

ROBERT W. HUNT CO., Consulting, Inspecting and Testing Engineers, F. M. Randlett, Vice-President and General Manager, Chicago, Ill.

INDIANA STEEL AND WIRE CO., Fred M. Crapo, Vice-President and General Manager, Muncie, Ind.

INTERNATIONAL HARVESTER CO., A. P. Cottle, Chairman, Materials and Standards Committee, Chicago, Ill.

THE STANDARD OIL CO. (OHIO), E. B. McConnell, Assistant General Manager, Manufacturing Dept., Cleveland, Ohio.

UNITED STATES GYPSUM CO., C. K. Roos, Director of Research and Development, Chicago, Ill.

The Firestone Tire and Rubber Co., represented by J. J. Allen, Chief Chemist, Mechanical Rubber Goods Division, Akron, Ohio, will become a sustaining member at the beginning of the next fiscal year, January 1, 1940.

These eight companies have been members for many years and have actively participated in committee work and the development of standards. Their decision to lend increased financial support to the Society's work through sustaining membership is appreciated greatly by the Executive Committee, which invites other companies to consider this form of membership.

Chicago District Meeting

UNDER the auspices of the Chicago District Committee, a meeting of members and guests was held in the Electric Association Restaurant in the Civic Opera Building on May 18. There was an attendance of about 75. General arrangements for the meeting were made by the officers of the Chicago District including D. L. Colwell, *chairman,* C. E. Ambelang, *secretary,* and J. F. Calef, chairman of the Program Committee.

Following the dinner, Mr. Colwell called attention to the importance of district meetings and their purposes, welcomed the guests, and then introduced Secretary-Treasurer Warwick. The Secretary-Treasurer spoke briefly on the growth of committee activities and the formation of new committees. He also mentioned the new procedure to be followed in distributing the triennial standards in three volumes, thereby giving members an opportunity to obtain those standards that are of particular interest to them.

The subjects of the evening's talks related to ordnance material. Lt. Col. A. B. Johnson of the Ordnance Department, U.S.A., spoke on "Mobilization of Industry." He indicated the progress being made by the U. S. Army in arranging for procurement of the many items needed by the Ordnance Division, particularly in relation to expediting manufacturing during a war emergency. He said it was necessary to have up-to-date standards on materials and testing for use by the manufacturers and indicated the large amount of work being done by the Army to obtain material of the proper type from a variety of manufacturers.

Numerous manufacturers are being given so-called educational orders for the tooling up of their plants to produce equipment and supplies on a large production basis. These educational orders, it is believed, will give the Army suppliers an excellent opportunity to educate their own organization in preparation of tools, equipment, and gages necessary to meet the Ordnance Department standards.

Supplementing Lt. Col. Johnson's talk was a short address by W. R. Wright of Ford, Bacon & Davis, Inc., formerly an officer in the Ordnance Department. Mr. Wright cited that there were numerous cases of trouble encountered in his work as inspector of ordnance during the World War. It was apparent that the manufacturers had difficulty in meeting some of the vague and incomplete specifications submitted. Mr. Wright believed that knowledge of some of the defects of the last war was important in order to appreciate the desirability of complete and workable standards for the present situation.

Discussion of Annual Meeting Papers

Written discussion of the papers and reports presented at the 1939 annual meeting in Atlantic City will be received by the Committee on Papers and Publications until September 1. However, all who plan to submit discussion are urged to send it to Society Headquarters as far in advance of this date as possible in order to facilitate preparation of material for the *Proceedings.* Discussion adds considerably to the value of the technical material published in the *Proceedings* and all those who may have additional material to submit, or wish to offer constructive comments, are urged to do so.

District Committee Appointments

THE several District Committees of the Society are organized in such a way that approximately one-third of the membership terms expire each year and accordingly with this plan of staggering the membership, appointments are made annually by the President. For the term 1939 through 1941, inclusive, the following appointments have been made:

Chicago: *H. B. Emerson, H. D. Browne, D. L. Colwell, F. R. McMillan, H. H. Morgan, F. A. Randall.

Cleveland: *R. H. Danforth, *G. A. Reinhardt, *E. C. Smith, A. W. Carpenter, Zay Jeffries, H. A. Schwartz, E. E. Ware.

Detroit: *Sidney Bevin, *F. P. Zimmerli, Martin Castricum, W. C. DuComb, E. W. Upham.

New York: *F. F. Farnsworth, W. H. Finkeldey, G. O. Hiers, C. A. Lunn, L. F. Rader.

No. California: Dozier Finley, G. H. Raitt, J. B. Terry.

Philadelphia: Alexander Foster, H. M. Hancock, R. W. Orr, F. G. Tatnall.

Pittsburgh: James Aston, Max Hecht, F. M. Howell, W. A. Selvig, J. J. Shuman.

So. California: *W. C. Hanna, E. F. Bent, H. W. Jewell.

* New appointments; all others re-appointments.

The complete personnel of District Committees, including chairmen, secretaries and vice-chairmen, will appear in the 1939 edition of the Year Book.

Southern California District Meeting

"SOME Modern Developments in Synthetic Plastics and Their Application to the Engineering Field" was the subject of a dinner meeting arranged by the Southern California District Committee. The meeting was held on April 24. R. B. Stringfield, leading technologist for many years in the subject of plastics, presented the main talk, indicating among other points the very rapid advance and widespread use of modern plastics. Arrangements for this meeting were in the charge of E. O. Slater, Smith-Emery Co., secretary of the district committee.

1940 Meetings in Detroit and Atlantic City

DECISION has been reached by the Executive Committee, after considering various factors involved, to hold the 1940 (Forty-Third) Annual Meeting of the Society at Chalfonte-Haddon Hall, Atlantic City, from June 24 to 28 inclusive. No formal exhibit of testing apparatus and related equipment will be held at this time.

Two of the technical features which are very likely to develop are a formal Symposium on Spectrochemical Analysis, the forerunner of which was the interesting round-table discussion held at this year's meeting. In connection with this symposium, which will be developed by Committee E-2 on Spectrographic Analysis, it is of interest to note the plans of Committee E-3 on Chemical Analysis of Metals which in joint cooperation with a division of the American Chemical Society will sponsor a Symposium on Analytical Methods.

On invitation of the Detroit District Committee, the Society will hold its 1940 Regional Meeting and Spring Group Meetings of Committees at the Hotel Statler in Detroit, the Regional Meeting being scheduled for March 6 during A.S.T.M. Committee Week which extends from March 4 to 8, inclusive. A Symposium on New Materials in Transportation dealing with the fields of aircraft, automotive, and railroads is to be the main feature of the Regional Meeting.

XXIII. Long-Time Society Committee Members

Twenty-third in the Series of Notes on Long-Time Members

As a continuation of the series of articles in the ASTM BULLETIN comprising notes on the outstanding activities of long-time A.S.T.M. members, there are presented below outlines of the work of three additional members. In general the men whose activities are described in this series have been affiliated with the Society for 25 years or more and have taken part in committee work for long periods of time. No definite sequence is being followed in these articles.

W. E. EMLEY, Chief, Organic and Fibrous Materials Division, National Bureau of Standards, Washington, D. C., is a graduate of the University of Michigan, receiving his B.S. degree in 1906 and Ch.E. degree in 1912. He has been with the National Bureau of Standards practically continuously since 1909 and for many years was Chief of the Section on Lime and Gypsum. He has been in his present position since 1926.

Very active in a number of important phases of A.S.T.M. work, he has been a member of the Society since 1911. From

James Aston

W. E. Emley

Frank Zeleny

1922 to 1926 he was secretary of the former Committee C-3 on Brick (now part of Committee C-15 on Masonry Units), was chairman of Subcommittee on Testing Methods of Committee C-7 on Lime and for seven years beginning in 1919 was chairman of Committee C-11 on Gypsum. He also headed the subcommittee of Committee D-13 on Textile Materials dealing with testing methods, and is a former chairman of the Technical Committees on Plasticity and Thickness of Committee E-1. His term as a member of Committee E-6 on Papers and Publications ran from 1935 to 1938.

At the present time, Mr. Emley is chairman of the Subcommittee on Paper Testing Methods of Committee D-6 on Paper and Paper Products; is chairman of Committee D-20 on Plastics, and serves on Committee D-11 on Rubber Products and on Committee E-1 on Methods of Testing.

He is a member of a large number of scientific and related organizations including Washington Academy of Sciences, American Chemical Society, American Institute of Chemical Engineers, United States Institute for Textile Research, American Leather Chemists Assn., Chairman of Subcommittee on Miscellaneous Materials and Accessories, National Advisory Committee for Aeronautics; Member of Advisory Committee for Scientific Research, The Textile Foundation; Member of Research Committee, National Association of Hosiery Manufacturers.

JAMES ASTON, Consulting Metallurgist, although a native of England, received his technical training in this country. At the University of Wisconsin he received his degree of B.S. in E.E. in 1898, Ch.E. in 1912, and Doctor of Science in 1933. For ten years until 1908 he was an engineer in the steel and foundry business; then for four years was research engineer on iron alloys at the University of Wisconsin. For three years he was Professor of Metallurgy at the University of Cincinnati, and the following year was at the U. S. Bureau of Mines as metallurgical engineer. From 1916 to 1926 he was metallurgist, A. M. Byers Company. Then he renewed his teaching and became Professor of Mining and Metallurgy and Head of that department at Carnegie Institute of Technology, serving from 1926 to 1935. One of his most important technical achievements was the invention of a process for mechanical working of wrought iron in place of hand puddling. A member of a large number of technical societies, including many in the field of mining and metallurgy, he was awarded the Hunt Medal by the A.I.M.E.

Doctor Aston's affiliation with the Society dates from 1912. The next year he became a member of Committee A-5 on Corrosion of Iron and Steel on which he has served continuously. From 1924 to 1936 he was secretary, helping to direct a number of very important projects which the committee instituted. He has been a member of Committee A-2 on Wrought Iron for over 20 years, and is at present chairman of three of its subgroups. He is also a representative of the American Railway Engineering Assn. on Committee B-2 on Non-Ferrous Metals and Alloys and represents the American Society of Heating and Ventilating Engineers on Committee D-19 on Water for Industrial Uses. He is Vice-Chairman of the Pittsburgh District Committee.

FRANK ZELENY, Engineer of Tests, Chicago, Burlington & Quincy Railroad Co., Aurora, Ill., is a native of Hutchinson, Minn. He was educated in the Minneapolis public schools and in 1898 received the degree of Mechanical Engineer from the University of Minnesota. In the fourth year at the University he specialized in railway mechanical engineering. He became interested in railroad work as the result of a friendship with a neighbor who was a locomotive engineer on the C. B. & Q. R.R.

His entire industrial experience has been with this railroad company. He started as a special apprentice which included service in various departments of the railroad. Previous to his present position, he was Assistant to the Superintendent of Shops at Aurora.

Mr. Zeleny has been a member of the Society since 1913 and in that year he became a member of Committee A-1 on Steel on which he has served continuously. He is a member of the following subcommittees: Advisory, IV on Spring Steel and Steel Springs, VI on Steel Forgings and Billets, VII on Rolled Steel Wheels and Steel Tires, and XI on Boiler Steel. His work on Committee A-2 on Wrought Iron began in 1916. He is a member of Subcommittees I on Tubes and Pipe and X on Research. Formerly he was a member of Committee D-11 on Rubber Products. Mr. Zeleny is a member of the American Association of Railroads, Mechanical Division, serving on the Committee on Specifications for Materials and on the Committee on Tank Cars.

New and Revised Tentative Standards Approved; Withdrawals Listed for Members' Convenience

THE Society accepted at the annual meeting 56 new tentative standards and revisions of 55 existing tentative specifications and methods of test. Of the new tentative standards 13 are revisions of existing standards—these are indicated in the following list. Nine of the 55 revised tentative specifications and test methods represent extensive modifications. The titles of these are included below (marked with an asterisk) with the list of those issued by the Society for the first time. Standing committees responsible for the various items are indicated in italics. The number of new tentative standards is the second largest that has ever been approved at an annual meeting.

New and Revised Tentative Standards

Ferrous Metals

Specifications for:

Seamless Alloy-Steel Boiler and Superheater Tubes (A 213 – 39 T). *Committee A-1 on Steel.*

Electric-Resistance-Welded Steel Heat-Exchanger and Condenser Tubes (A 214 – 39 T). *Committee A-1.*

Carbon-Steel Castings Suitable for Fusion Welding for Miscellaneous Industrial Uses (A 215 – 39 T). *Committee A-1.*

Carbon-Steel Castings Suitable for Fusion Welding for Service at Temperatures up to 850 F. (A 216 – 39 T). *Committee A-1.*

Alloy-Steel Castings Suitable for Fusion Welding for Service at Temperatures from 750 to 1100 F. (A 217 – 39 T). *Committee A-1.*

*Electrodeposited Coatings of Zinc on Steel (A 164 – 39 T). *Committee A-5 on Corrosion of Iron and Steel.*

*Electrodeposited Coatings of Cadmium on Steel (A 165 – 39 T). *Committee A-5.*

*Electrodeposited Coatings of Nickel and Chromium on Steel (A 166 – 39 T). *Committee A-5.*

Zinc-Coated Steel Wire Strand (Galvanized and Extra Galvanized) (A 122 – 39 T) (revision of standard). *Committee A-5.*

Zinc-Coated Steel Wire Strand (Class B and Class C Coatings) (A 218 – 39 T). *Committee A-5.*

Pearlitic Malleable Iron Coatings (A 220 – 39 T). *Committee A-7 on Malleable-Iron Castings.*

Methods of:

Test for Local Thickness of Electrodeposited Coatings on Steel (A 219 – 39 T). *Committee A-5.*

*Test for Interlamination Resistance and Lamination Factor of Steel (A 34 – 39 T) (revision of standard). *Committee A-6 on Magnetic Properties.*

Non-Ferrous Metals

Specifications for:

Figure 9 Deep-Section Grooved and Figure 8 Copper Trolley Wire for Industrial Haulage (B 116 – 39 T). *Committee B-1 on Copper and Copper-Alloy Wires for Electrical Conductors.*

Copper Pipe, Standard Sizes (B 42 – 39 T) (revision of standard). *Committee B-5.*

Brass Pipe, Standard Sizes (B 43 – 39 T) (revision of standard). *Committee B-5.*

Seamless Copper Tubing, Bright Annealed (B 68 – 39 T) (revision of standard). *Committee B-5.*

Classification of Cast Copper-Base Alloys (B 119 – 39 T). *Committee B-5.*

Beryllium-Copper Bars, Rods, Sheet, Strip, and Wire (B 120 – 39 T). *Committee B-5.*

Leaded Brass Sheet and Strip (B 121 – 39 T). *Committee B-5.*

Copper-Nickel-Zinc and Copper-Nickel Alloy Sheet and Strip (B 122 – 39 T). *Committee B-5.*

Leaded Nickel-Brass and Leaded Nickel-Bronze (Nickel-Silver) Alloys in Ingot Form for Sand Castings (B 123 – 39 T). *Committee B-5.*

Copper-Base Alloy Forging Rods, Bars, and Shapes (B 124 – 39 T) (revision of standard). *Committee B-5 on Copper and Copper Alloys.*

Aluminum Ingots for Remelting (B 24 – 39 T) (revision of standard). *Committee B-7 on Light Metals and Alloys.*

Aluminum for Use in Iron and Steel Manufacture (B 37 – 39 T) (revision of standard). *Committee B-7.*

Aluminum-Base Alloys in Ingot Form for Die Castings (B 125 – 39 T). *Committee B-7.*

Methods of:

Salt Spray Testing of Non-Ferrous Metals (B 117 – 39 T). *Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys.*

Testing Nickel and Nickel-Alloy Wire and Ribbon for Electronic Tube Filaments (B 118 – 39 T). *Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys.*

*Test for Flexivity of Thermostat Metals (B 106 – 39 T). *Committee B-4.*

Metallography

Methods of:

Preparation of Metallographic Specimens (E 3 – 39 T) (revision of standard). *Committee E-4 on Metallography.*

Cement

Methods of:

*Chemical Analysis of Portland Cement (C 114 – 39 T). *Committee C-1 on Cement.* New alternate procedures for determination of free calcium oxide in cement.

Concrete and Concrete Aggregates

Specifications for:

Aggregate for Masonry Mortar (C 144 – 39 T). *Committee C-12 on Mortars for Unit Masonry.*

Solid Load-Bearing Concrete Masonry Units (C 145 – 39 T). *Committee C-15 on Manufactured Masonry Units.*

Refractories

Methods of:

Test for Fireclay and Alumina-Diaspore Refractories Under Load at High Temperatures (C 16 – 39 T) (revision of standard). *Committee C-8 on Refractories.*

*Test for Size and Bulk Density of Refractory Brick (C 134 – 39 T). *Committee C-8.*

*Testing Insulating Fire Brick (Compressive Strength, Flexural Strength, and Permanent Linear Change After Heating) (C 93 – 39 T). *Committee C-8.*

Pigments and Paint

Specifications for:

Shellac Varnishes (D 359 – 39 T) (revision and combination of standards D 359 and D 360). *Committee D-1 on Paint, Varnish, Lacquer, and Related Products.*

Zinc Dust (Metallic Zinc Powder) (D 520 – 39 T). *Committee D-1.*

Methods of:

Chemical Analysis of Zinc Dust (Metallic Zinc Powder) (D 521 – 39 T). *Committee D-1.*

Test for Elongation of Attached Lacquer Coatings with the Conical Mandrel Test Apparatus (D 522 – 39 T). *Committee D-1.*

Test for Specular Gloss of Paint Finishes (D 523 – 39 T). *Committee D-1.*

Test for Toluene (Toluol) Dilution Ratio of Lacquer Solvents (D 268 – 39 T) (revision of standard). *Committee D-1.*

Petroleum Products and Lubricants

Methods of:

Test for Carbon Residue of Petroleum Products (Ramsbottom Carbon Residue) (D 524 – 39 T). *Committee D-2 on Petroleum Products and Lubricants.*

Test for Gum Stability of Gasoline (D 525 – 39 T). *Committee D-2.*

Test for Tetraethyl Lead in Gasoline (D 526 – 39 T). *Committee D-2.*

Waterproofing and Roofing Materials

Specifications for:

Asphalt Mastic for Use in Waterproofing (Asphalt Cement, Mineral Filler, Mineral Aggregate) (D 491 – 39 T) (revision and combinations of Specifications D 169, D 223, and D 491). *Committee D-8 on Bituminous Waterproofing and Roofing Materials.*

Recommended Practice for:

Accelerated Weathering Test of Bituminous Materials (D 529 – 39 T). *Committee D-8.*

Paper

Methods of:

Test for Machine Direction of Paper (D 528 – 39 T). *Committee D-6 on Paper and Paper Products.*

Test for Bulking Thickness of Paper (D 527 – 39 T). *Committee D-6.*

RUBBER

Specifications for:

Rubber Sheath Compound for Cords and Cables (D 532 – 39 T). *Committee D-11 on Rubber Products.*

Methods of:

Testing Hard Rubber Products (D 530 – 39 T). *Committee D-11.*

Test for Indentation of Rubber by Means of the Pusey and Jones Plastometer (D 531 – 39 T). *Committee D-11.*

SOAPS AND DETERGENTS

Specifications for:

Built Soap, Powdered (D 533 – 39 T). *Committee D-12 on Soaps and Other Detergents.*

Soap Powder (Alkaline Soap Powder) (D 534 – 39 T). *Committee D-12.*

Palm Oil Bar Soap (D 535 – 39 T). *Committee D-12.*

Palm Oil Chip Soap (D 536 – 39 T). *Committee D-12.*

Sodium Metasilicate (D 537 – 39 T). *Committee D-12.*

Trisodium Phosphate (D 538 – 39 T). *Committee D-12.*

Methods of:

Sampling and Chemical Analysis of Special Detergents (Trisodium Phosphate, Sodium Metasilicate, Carbon Dioxide in Caustic Soda) (D 501 – 39 T). *Committee D-12.*

Definitions of:

*Terms Relating to Soaps and Other Detergents (D 459 – 39 T) four revised and six new definitions. *Committee D-12.*

TEXTILE MATERIALS

Methods of:

Test for Apparent Fluidity of Dispersions of Cellulose Fibers in Cuprammonium Hydroxide (D 539 – 39 T). *Committee D-13 on Textile Materials.*

Testing Rayon Staple (D 540 – 39 T). *Committee D-13.*

Testing and Tolerances for Single Jute Yarns (D 541 – 39 T). *Committee D-13.*

PLASTICS

Methods of:

Test for Index of Refraction of Transparent Organic Plastics (D 542 – 39 T). *Committee D-20 on Plastics.*

Test for Resistance of Plastics to Chemical Reagents (D 543 – 39 T). *Committee D-20.*

Standards and Tentative Standards Withdrawn and Replaced

Actions at the annual meeting based on the various standing committee recommendations as detailed in the preprinted reports resulted in the withdrawal of a number of standards and tentative standards.

In reviewing the accompanying list, it should be kept definitely in mind that in a great many cases the items withdrawn have been replaced by other specifications or tests accepted at the 1938 meeting (these are listed above under New and Revised Tentative Standards) or in a few cases by items issued previous to this year.

Full details of all of the actions affecting the standards and tentative standards are given in the Summary of Proceedings which is being sent to each member in a separate mailing.

STANDARD Specifications for:

Steel for Buildings (A 9 – 36), combined with Standard Specifications A 7 – 39.

Quenched and Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 – 36) to be replaced by new Tentative Specifications.

Arbitration Test Bar and Tension Test Specimen for Cast Iron (A 124 – 29).

Fireclay Brick for Marine Boiler Service (C 65 – 28).

STANDARD Methods of:

Determining Weight of Coating on Tin, Terne, and Lead-Coated Sheets (A 91 – 24).

TENTATIVE Specifications for:

Carbon-Steel Forgings for Locomotives (A20 – 31 T) to be replaced by New Tentative Specifications.

Asphalt Cement, 10 to 15 Penetration, for the Manufacture of Asphalt Block (D 133 – 23 T).

Asphalt Cement, 15 to 25 Penetration, for the Manufacture of Asphalt Block (D 134 – 23 T).

Asphalt Cement, 25 to 30 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements (D 163 – 23 T).

Asphalt Cement, 30 to 40 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements (D 164 – 23 T).

Asphalt Cement, 40 to 50 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements and as Filler for Brick and Block Pavements (D 99 – 26 T).

Asphalt Cement, 50 to 60 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements and as Filler for Block Pavements (D 100 – 26 T).

Asphalt Cement, 60 to 70 Penetration, for Use in Sheet Asphalt Asphaltic Concrete and Asphalt-Macadam Pavements and as Filler for Block Pavements (D 101 – 26 T).

Asphalt Cement, 85 to 100 Penetration, for Use in Asphalt-Macadam Pavements (D 102 – 24 T).

Asphalt Cement, 100 to 120 Penetration, for Use in Asphalt-Macadam Pavements (D 103 – 24 T).

Asphalt Cement, 120 to 150 Penetration, for Use in Asphalt-Macadam Pavements (D 135 – 23 T).

Rubber Pump Valves (D 151 – 31 T).

TENTATIVE Methods of:

Test for Expressible Oil and Moisture in Paraffin Waxes (D 308 – 29 T).

Concrete Manual

THE Second Edition of this Manual for the Control of Concrete Construction has been issued by the United States Department of the Interior, Bureau of Reclamation, Office of Chief Engineer, Denver, Colo. The demand for the book, rather than the necessity of revision of the First Edition of July, 1938, necessitated this Second Edition, and while some corrections were made as well as certain alterations in figures and text, it is indicated that the Second Edition may be regarded virtually as a reprint. Part I of this Manual covers concrete and its ingredients; Part II is devoted to investigations prior to construction, followed by Part III on construction control including inspection and reports, concrete manufacturing, handling, placing and curing, etc.; Part IV includes various appendices covering methods for sampling and testing, the field laboratory, concrete segregation, mix tables, and the like. Reference is made to a number of the Society's specifications and tests. There is a detailed subject index. Copies of this 454-page publication, page size, 4¼ by 7¼ in., can be obtained from the Bureau of Reclamation, Denver, Colo., and Washington, D. C., at $1 per copy, which includes postage to Canada, Mexico and the United States and its possessions; postage to other foreign countries, 12 cents extra.

Heating Ventilating Air Conditioning Guide Issued

THERE has recently been issued by the American Society of Heating and Ventilating Engineers the 1939 edition of the Heating Ventilating Air Conditioning Guide. This latest edition includes the largest technical data section in any of the volumes yet issued. There are 856 pages arranged in the form of 45 chapters, devoted to technical data. The section giving reference material on the design and specification of various systems covers various research investigations and various practices. Also given is a Manufacturers' Catalog Data Section and the Roll of Membership of the Society. There are complete indexes to the Technical Section and the Catalog Data Section. A large number of authorities cooperated in the preparation of this volume. Copies can be obtained from the American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York City. The price of the Guide is $5 per copy for the regular edition and $5.50 per copy for the de luxe edition with thumb index.

Standardization Activities Under Way

Numerous Specifications and Tests Being Developed

IN the material which follows there is given condensed information on a number of important standardization activities including several items which are nearing completion and which are expected to be submitted to Committee E-10 on Standards late in August for approval. Also mentioned are a number of other items where active progress is being made. In many cases this information supplements reviews of committee work appearing in the annual reports of the committees.

FERROUS METALS AND PRODUCTS

Intensive work on the part of Committee A-1 has resulted in six proposed specifications covering various types of spring wire (music, carbon and chromium-vanadium valve spring, hard drawn, chromium-vanadium and oil tempered) which are being submitted to the Society through Committee E-10. Other recommendations include requirements for manganese-vanadium steel plates for boilers and other pressure vessels and specifications for electric-resistance welded steel boiler and superheater tubes for high-pressure service. Among other important projects which should result in new specifications within the next year or so is one involving so-called low alloy and related steels suitable for fusion welding. A special group consisting of subcommittee chairmen and the chairman of Committee A-1 are acting as a coordinating group.

In order to bring the Society requirements for cast-iron soil pipe and fittings and cast-iron pit cast pipe for water or other liquids in line with specifications developed by A.S.A. Sectional Committees new specifications will be submitted by Committee A-3 to replace respectively the existing standard specifications A 74–29 and A 44–04. Accompanying these will be a new specification for cement mortar lining for cast-iron pipe and fittings.

The preparation of additional specifications will be continued by Committee A-5 on Corrosion of Iron and Steel. Particular attention will be given in the next year to a study of specifications for zinc coatings on hardware articles and fastenings. A tentative specification on these products has been in existence for some time. The desirability of breaking up this rather general specification into a series of individual specifications dealing with specific products, such as nuts, bolts, etc., is now being considered. The revision and amplification of the present specifications for zinc-coated chain link fence fabric is also under consideration.

The committee's work on testing methods in the immediate future will be very similar to its activity in this field for the past few years and will deal largely with the development of better Preece Test methods for the determination of uniformity of zinc coatings on iron and steel hardware articles, with particular reference to nuts and bolts.

For several years the investigation and perfection of various testing methods has been concerned principally with protective coatings for iron and steel products, largely because of the interest and activity in this subject by the subcommittee on specifications for metallic-coated products and the subcommittee on the field tests of metallic coatings. Work will probably continue along these lines until such a time as the work of Committee A-5 is broadened to include corrosion investigations of iron and steel products under service conditions other than atmospheric.

In its work on magnetic properties, Committee A-6, has inaugurated two cooperative investigations, one on the development of standard methods for measuring incremental permeability and the other a study of the possibility of using a smaller sample of material than at present specified for the determination of core losses together with the possible use of the same magnetic circuit for measuring a-c permeability. This program is likely to require more than a year for completion.

The active program of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys includes the development of a recommended practice for testing materials in boiling liquid and another for testing under conditions of atmospheric exposure. A detailed review of chromium-nickel steel castings is being considered, particularly in view of the large amount of new data in course of development. Work on specifications for corrosion-resisting steel tubing is being carried out, contacts being made with the steel committee's subgroups. It is expected the Guide for Conducting Plant Corrosion Tests, published as information in A-10's preprinted annual report, will be submitted to the Society for approval as a tentative recommended practice.

NON-FERROUS METALS AND ALLOYS

Proposed tentative specifications for soft rectangular copper wire have been developed by Committee B-1 to replace the existing standard B 48. Two grades of wire are being included, one applicable for edgewise bending purposes and the other suitable for all applications except extreme bending. Several other changes are intended to bring the new specifications in line with current industrial practices.

Of considerable importance are recommendations being developed by Committee B-2 on Non-Ferrous Metals and Alloys, including a revision of the standard specifications for pig lead (B 29) providing for the addition of three proposed new grades. A replacement of the existing standard for solder metal is contemplated through new specifications for soft solder metal. Demand for standardized requirements for monel metal sheet, plates and other rolled products will be met in a proposed new tentative specification.

In order to keep specifications for die castings in line with developments in the art some minor changes are contemplated by Committee B-6, particularly involving the lead- and tin-base and the magnesium die-casting alloys.

A proposed specification for aluminum-manganese alloy sheet and plate for use in welded pressure vessels has been completed and is being submitted to the Society for publication in the new Book of Standards. Work on methods of testing anodic coatings, particularly in connection with the Abrasimeter test will be continued. Committee B-7 on Light Metals and Alloys, Cast and Wrought, also hopes to present next year a method for testing coating thickness by weight measurements. Revisions of the tentative method of test for

dielectric strength of anodized aluminum (B 110) have been completed.

CERAMIC, CONCRETE AND MASONRY MATERIALS

Committee C-8 on Refractories is investigating the advisability of a study of refractory service conditions in boiler plants, a special group being in course of development to prepare this survey. Further research work involving the panel spalling test is being considered. C-8's section on temperature is making a study of test cones with special consideration of the effect of size and dimensions on precision and reproducibility.

The program of work being scheduled by Committee C-9 on Concrete and Concrete Aggregates involves the following: a proposed specifications for stone sand; a comparative study of the several soundness tests in current use; a possible revision of the present specifications for ready mixed concrete, into two parts; one, recommended practices; the other, the specification requirements proper; improvement of the method of sampling wet concrete; and the development of a method of comparing the uniformity of concrete as mixed by a given piece of mixing equipment.

Intensive work by Committee C-14 on Glass and Glass Products has resulted in the preparation of four proposed tentative methods as follows: chemical analysis of glass sand; polariscopic examination of glass containers; hydrostatic pressure test on glass containers; and thermal shock test on glass containers. These items will be submitted to Committee E-10 for approval as tentative for publication in the new Book of Standards.

Committee C-15 on Manufactured Masonry Units plans to recommend a revision in the standard methods for testing brick (C 67) to provide for inclusion of two alternate methods for freezing-and-thawing tests. Changes are also to be made in the requirements for sewer brick (C 32) and for building brick (C 62).

PAINTS, GASEOUS FUELS, COAL AND COKE, NAVAL STORES, PAPER, ETC.

Some of the work of Committee D-1 on Paint, Varnish, Lacquer, and Related Products includes methods for determining gas resistance of varnishes, for evaluating failures of varnishes upon exposure, for measuring the color of dried varnish films and for determining the chemical resistance of furniture and floor varnishes. Standardizing specifications and tests on metallic dryers is being started; also a study of methods for analyses for alkyd resin vehicles. Various proposed procedures for determining solvencies of paint thinners are to be examined cooperatively.

With reference to shellacs and varnishes, tests for quality, color, wax, and adulterants are now being considered and tests are being developed for evaluating those properties of lacquers which, while not a part of normal specifications, are of value in determining the usefulness of certain cellulose ester coatings. For example, a tentative method for the determination of the elongation of attached lacquer films has been established and a method for determining the abrasion resistance of attached films is being developed.

A physical test method for measuring the consistency of paint and enamel is being drafted. In the field of pigments, the present work includes an investigation on the percentages of hygroscopic moisture to be expected in dry pigments which have been normally packed and stored.

Work is to be commenced shortly on specifications for carbon black and careful study is being given to a revision of the specifications for leaded zinc oxide, particularly with respect to the ratio of lead to zinc.

Committee D-3 on Gaseous Fuels is continuing experimental work on the comparison of methods that are used in connection with the purchase and sale of gaseous fuels and in the application of public utility standards. Particular attention is being given to methods of sampling manufactured, natural, and liquefied petroleum gases and in the testing of small wet gas meters under various conditions of operation and at various rates of flow. This work is being done at the National Bureau of Standards where other studies also are in progress with reference to equipment in common use for specific gravity determinations and the complete analysis of gaseous fuels.

On determination of water vapor content of gaseous fuels, a study of the thermo-conductivity method was completed during the year. It was not found satisfactory either for field or precision work and studies have been initiated on two other methods.

Work is being continued on a study of referees' apparatus for the determination of total sulfur in gaseous fuels. Also studies are being made on the determination of impurities other than sulfur. A determination of calorific value of gaseous fuels by means of the water-flow calorimeter is being standardized.

Committee D-5 on Coal and Coke is investigating methods for determination of ash of coals high in calcite ($CaCO_3$) and pyrite (FeS_2). It is difficult for different laboratories to obtain check results with such coals when using the standard method for ash because the amount of sulfur fixed in the ash as calcium sulfate ($CaSO_4$) depends largely on the rate of burning off the organic matter. Various modified procedures are being investigated.

The committee is still trying to work out a satisfactory revision of the present tentative specifications for foundry coke. This may be a broad classification of foundry cokes into various grades rather than a definite specification; or it may list the various physical and chemical properties affecting the use of coke in the cupola with desirable limits of these factors.

Methods suitable for sampling large-sized coal and for sampling run-of-mine-coal are being studied. Advantage is to be taken of the Committee E-10 procedure to submit for publication as tentative a proposed test for index of dustiness of coal and coke. This was preprinted in the annual report of the committee. When approved, it will be tried out further by the coal industry so more data will be available regarding its value for testing dusting characteristics.

In connection with plasticity and swelling of coal, a series of cooperative tests on seven coking coals having been concluded, it has been decided to make other tests under more closely controlled conditions. Two procedures for testing expansion characteristics will be drafted in standard form so that all cooperating laboratories will follow exactly the same procedure.

ROAD AND PAVING MATERIALS, PAPER PRODUCTS, RUBBER, SOAP

Recommendations to be made to the Society through Committee E-10 procedure by Committee D-4 on Road and Paving Materials include approval as tentative of three items published in the preprinted report for information, namely, test for sieve analysis of mineral filler; specifications for preformed expansion joint fillers for concrete; and methods of testing preformed expansion joint fillers for concrete which includes four types, cork, self-expanding cork, sponge rubber and cork rubber.

At its meeting in Atlantic City, Committee D-6 on Paper and Paper Products decided to submit to letter ballot three proposed methods with the intention that they would be submitted to Committee E-10. The methods cover the determination of starch in paper; of water-soluble acidity or alkalinity of paper; of resin in paper.

Two proposals are expected to be made by Committee D-11 on Rubber Products, one involving a new method of test for the effect of compression hysteresis on vulcanized rubber and a revision of the existing standard test for hardness of rubber (D 314) to include a method for hard rubber ash analysis.

Committee D-12 on Soaps and Other Detergents reports that in addition to the work completed during the year, it is preparing specifications and methods of tests for liquid and paste soap, scouring powders and soaps, and other phosphates and silicates, low titer soaps, olive oil soap, potash soaps, etc. It is also working on the problem of evaluating detergency, a very difficult problem. A study is also being made of dry cleaning and metal cleaning detergents.

NAVAL STORES, SOILS, PLASTICS

Concerning Committee D-17 on Naval Stores, the results of the comparison of the use of the shouldered and tapered rings for determining softening point of modified rosins indicates the need of further work on such rosins, and possibly on some synthetic resins. The development of a method for the determination of the crystallizing of rosins will be continued.

The difficulty experienced in determining the end point of the titration in determining the saponification number of dark rosins requires additional study.

Active interest in the work on soils for engineering materials is indicated by a letter ballot being conducted in Committee D-18 providing for submission to Committee E-10 the following four methods: moisture-density relations of soil-cement mixtures; durability of compacted soil-cement mixtures by repeated freezing and thawing; durability of compacted soil-cement mixtures by repeated wetting and drying; and stabilization of soils with emulsified asphalt.

The first tentative methods of test proposed by Committee D-20 on Plastics were acted on at the annual meeting in Atlantic City. These involved an index of refraction of transparent organic plastics and resistance of plastics to chemical reagents. Another tentative method involving testing the flow of thermoplastic molding materials has been completed and will be submitted to the Society during the summer. Several other test methods are being considered by the D-20 subcommittees involving strength, hardness, thermal, optical and permanence properties.

SPECTROGRAPHY, METALLOGRAPHY

The Subcommittee on Methods, of Committee E-2 on Spectrographic Analysis, will carefully consider the criticisms and suggestions which have been made relative to existent tentative standard methods and will suggest some definite action by the committee. Subgroups have been asked to forward their work looking toward the extension of spectrographic methods to the analysis of other materials than those already covered, provided there is an actual need for such methods.

An active program confronts Committee E-4 on Metallography including the correlation of methods of dilatometric analysis and the compilation of an up-to-date set of definitions to replace existing ones (E 7). The committee is submitting two tentative methods for approval, one covering standard rules governing the preparation of micrographs of metals and alloys (a revision of E 2); the other covering a tentative standard for classification of austenite grain size in steel. The latter will include both the idealized chart from E 19–38 T and the McQuaid-Ehn chart from the old standard E 19–33.

Symposium on the Chemistry of Cements

THE extensive publication comprising the Symposium on the Chemistry of Cements held in Stockholm in 1938 under the auspices of The Royal Swedish Institute for Engineering Research and The Swedish Cement Association has recently been issued. The technical papers forming the basis of the symposium are comprehensive ones on the following subjects:

The Study of Giant Molecules by Means of Ultra-centrifugal Sedimentation, Diffusion and Electrophoresis—T. Svedberg.

Reactions Between Substances in Solid State with Special Regard to Systems Containing Silica—J. A. Hedvall.

Constitution of Portland Cement Clinker—R. H. Bogue.

X-rays and Cement Chemistry—W. Büssem.

The Calcium Aluminate and Silicate Hydrates—G. E. Bessey.

The Calcium Aluminate Complex Salts—F. E. Jones.

Portland Cement and Hydrothermal Reactions—T. Thorvaldson.

Effect of Water on Portland Cement—P. Schläpfer.

The Chemistry of Retarders and Accelerators—L. Forsén.

The Mineral Content of Aluminous Cement—N. Sundius.

Reactions of Aluminous Cement with Water—G. Assarsson.

The Chemistry of Pozzolanas—F. M. Lea.

The Physical Structure of Hydrated Cements—S. Giertz-Hedström.

Each paper is subdivided with divisions clearly marked and following each paper is given the discussion, a considerable portion of the volume being devoted to this. The authors of the papers and discussers are outstanding authorities from the various countries which participated, a number being from the United States including R. H. Bogue, M. A. Swayze, and P. S. Roller. There is a detailed subject index and an author index, as well as an informative and useful table of contents.

The complete book is published in English and is profusely illustrated with charts and diagrams. What appears to be a very excellent job of editing has been carried out by S. Giertz-Hedström, Secretary of the Symposium. Copies of this 578-page publication in blue cloth binding, page size 6½ by 9½ in., can be obtained from the Cementlaboratoriet, I.V.A., Stockholm 5, Sweden, at $7.50, plus 50 cents for postage.

Numerous Publications to be Issued

List Includes Several Special Items

In addition to the so-called regular publications, including the Book of Standards, *Proceedings,* Year Book, Index to Standards, etc., there are a number of special volumes to be issued within the next few months, these having been authorized by the Committee on Papers and Publications.

Brief notes on some of these publications are given below for the information of the members, and a list of all of the publications, with special prices to members and other descriptive information, will be sent in the form of an order blank to each member in September.

The special compilations of standards issued during the past few years have become of increasing significance and, as indicated below, new editions of these widely used books are to be published.

REGULAR PUBLICATIONS

1939 Book of A.S.T.M. Standards:

In line with the new publication policy, as set forth in a letter to the members dated November 8, 1938, the Book of Standards will this year be issued in three parts as follows:

Part I. Metals
Part II. Non-Metallic Materials—Constructional
Part III. Non-Metallic Materials—General

These volumes will also include the respective tentative standards and tentative revisions, which material will no longer appear in the *Proceedings.* It is expected that the Book of Standards will be ready for distribution by November 30.

Methods of Chemical Analysis of Metals:

This volume will continue to be issued as a separate publication, sent to members upon request. Ready about November 15.

1939 Proceedings:

This year the *Proceedings* will be issued as one volume, containing both committee reports and technical papers, together with the discussion thereof. Will be mailed about December 15.

Index to Standards and Tentative Standards:

This Index, which continues to increase in value as the number of specifications becomes larger, will again give the latest complete references to publications where the various specifications and test methods appear. The Index is furnished to members, and is also widely distributed, on request. Members may obtain additional copies without charge.

Year Book:

Includes a list of the complete membership of the Society (name, address, company, etc.), the personnel of all A.S.T.M. committees, and other pertinent information. Furnished to members on request. The sale of the Year Book to non-members has been discontinued. Publication date—September 15.

Symposium on Lime
and
Symposium on Thermal Insulating Materials:

These symposiums, held at the Columbus Regional Meeting of the Society in March, will be issued as two separate volumes, and should be available about September 15.

SPECIAL PUBLICATIONS

1939 Marburg Lecture:

The Marburg Lecture on "Stress, Strain and Structural Damage," delivered by Prof. H. F. Moore at the annual meeting, will be included in the 1939 *Proceedings;* prior to publication in the *Proceedings,* reprints of the lecture will be issued.

Special Compilations:

New editions of the special compilations of standards, covering specific industrial fields, will be made available during the latter part of this year. All of the A.S.T.M. standard and tentative specifications and tests in the following fields will be included in the respective volumes: steel piping materials, cement, petroleum products, electrical insulating materials, rubber products, and textile materials.

The very considerable task of bringing up to date the data in the Tables of Chemical Compositions, Physical and Mechanical Properties and Corrosion-Resistant Properties of Corrosion-Resistant and Heat-Resistant Alloys which were issued in 1930, is now before Committee A-10, and the revised tables may be available early in 1940.

Protective Coatings for Metals

The book, "Protective Coatings for Metals," by R. M. Burns, Assistant Chemical Director, Bell Telephone Labs., Inc., and A. E. Schuh, Director of Research, U. S. Pipe and Foundry Co., was published in April by the Reinhold Publishing Corp. At the time the book was in preparation Doctor Schuh was a member of the staff of the Bell Telephone Labs. This A.C.S. monograph series replaces and extends the scope of the former publication prepared by Dr. H. S. Rawdon in 1928. This work has been completely rewritten and covers coatings of all types, including paints. While designed primarily for those who have problems of protection, it includes considerable information on production phases of the subject.

Chapters are devoted to such topics as the following: protective coatings and the mechanism of corrosion; surface preparation for the application of coatings; types of metallic coatings and methods of application; zinc coating by hot-dipping process; zinc coating by electroplating and cementation; protective value of zinc coatings; cadmium coatings and their protective value; tin coatings; nickel and chromium coatings; coatings of copper, lead, aluminum and miscellaneous metals; coatings of noble and rare metals; methods of testing metallic coatings; composition of paints and mechanism of film formation; the durability and evaluation of paints; paint practices; and miscellaneous coatings.

Copies of this 407-page publication which includes a detailed author and subject index can be obtained from the publishers, 330 West Forty-second St., New York City, at $6.50 each.

Report of the Joint Research Committee on Boiler Feedwater Studies[1]

SINCE the presentation of a report of the activities of the Joint Research Committee on Boiler Feedwater Studies made a year ago,[2] the committee has been active in presenting programs at two society meetings.

At the annual meeting of the American Society of Mechanical Engineers, New York City in December, 1938, three papers or reports were presented: namely,

"Colorimetric Determination of Silica in Boiler Feedwater," by A. E. White,

"Alkalinity and Sulphate Relations in Boiler Water Salines," by J. H. Walker, and

"Third Progress Report of Committee No. 9 on Patents of the Boiler Feedwater Studies Committee," by S. T. Powell, chairman.

In connection with the Power Division of the A.S.M.E., a program of several important papers was presented at the New Orleans meeting of the A.S.M.E. and of the Louisiana Engineers Society. These papers were very well received and have since been the subject of a great deal of discussion and interest:

"Attack on Steel in High-Pressure Boilers as a Result of Overheating Due to Steam Blanketing," by Everett P. Partridge and R. E. Hall,

"Mechanical Purification of Steam Within the Boiler Drum," by M. D. Baker, and

"Corrosion in Partially Dry Steam Generating Tubes," by F. G. Straub and Elwood E. Nelson.

The work on caustic embrittlement, sponsored by Subcommittee No. 6 (J. H. Walker, chairman) at the U. S. Bureau of Mines laboratory at College Park, Md., has made important progress during the past twelve months. The general objectives have been (1) the search for effective chemical inhibitors through laboratory studies, and (2) the collection and correlation of data as to the embrittling characteristics of actual boiler waters.

Some promising inhibitors have been discovered and are being studied in the laboratory and in actual boilers. Chief among these are the wood extracts—lignin, quebracho, and cutch. They are being used with apparent success in certain cases but are not as yet to be generally recommended. It is the hope that eventually some inhibitors can be recommended which will so alter the chemical conditions of the boiler water as to render it incapable of attacking the boiler metal.

A valuable device known as the embrittlement detector has been developed which, attached to a boiler, shows whether or not the boiler water is embrittling in character. It is proving extremely useful in the collection of data from boiler plants, and a large number either have been or are being installed.

The proposed work on the determination of silica in boiler water which had been given some consideration by Subcommittee No. 8 on Methods of Analysis is not being pursued, at least for the present, because it was felt that too few operators had encountered the difficulties attendant upon operation with high silica concentration to enable the committee to stimulate the necessary interest to enlist the financial support of such a research project. Research on the general subject of silica in boiler water will again be considered when and if interest in it becomes manifest generally.

The work on coagulation and sedimentation of industrial waters as part of the Joint Research Committee's program has been in abeyance since the illness of Professor Black, chairman of Subcommittee I.

In lieu of a definite research project on corrosion, the attention of the membership of the sponsoring Societies is currently called to outstanding and important papers dealing with this subject. The committee welcomes advice with respect to research work in this field that may be of interest to others if publicly presented. Attention is called to a paper presented by the Detroit Edison Co. before the A.S.M.E. in December, 1938, which discussed certain aspects of the corrosion by steam of metals for high-temperature service. It is hoped that more papers on this subject will be available in the near future. The research work at Purdue University under the direction of Dean A. A. Potter and his associates, which concerns some of the more fundamental aspects of the problem of the corrosion of metals at elevated temperatures in an atmosphere of steam, is being continued. The progress has been slow; but the findings are of intense interest.

Subcommittee No. 9 on Patents in the field of water treatment for industrial boilers continues its activities and presented its 1938 report to the Executive Committee last December. Copies of that report are available for distribution to those interested.

The principal project of the committee continues to be, as in the past, its research on caustic embrittlement which is being efficiently directed by Subcommittee No. 6.

Respectfully submitted,

J. B. ROMER, *Secretary.*

[1] Presented at the Forty-second Annual Meeting, Am. Soc. Testing Mats., Atlantic City, N. J., June 26 to 30, 1939.

[2] ASTM BULLETIN, No. 93, August, 1938, p. 32.

New Technical Committee on Automotive Rubber Organized

AT a well-attended meeting held in Detroit on June 8, a new committee designated Technical Committee A on Automotive Rubber was organized under the auspices of Committee D-11 on Rubber Products.

Early this year the Society of Automotive Engineers had pointed to the urgent need for the development of recognized standards for so-called automotive rubber products. While Committee D-11 had been at work in this field, progress had been slow, partly due to lack of cooperation from consumer interests and the undeveloped state of standardized methods covering fundamental properties of rubber. More recently substantial progress has been made in the latter field and with the offer of cooperation on the part of the S.A.E., the decision was reached to form a technical committee with personnel drawn jointly from the producer members of Committee D-11 and representatives of major consuming interests in the automotive industry as recommended by the S.A.E.

At the meeting held in Detroit, L. A. Danse, Metallurgist, Cadillac Motor Car Division, General Motors Corp., was

Personnel of Technical Committee A on Automotive Rubber

Representative	Company	Alternate
* L. A. Danse, Metallurgist, *Chairman*	Cadillac Motor Car Div., General Motors Corp.	H. C. Mougey
** J. D. Morron, Manager, Motor Products Development, *Secretary*	United States Rubber Co.	
** M. Achterhoff, Chief Chemist	Ohio Rubber Co.	
** J. J. Allen, Chief Chemist, Mechanical Rubber Goods Division	The Firestone Tire and Rubber Co.	
** Chris Bockius	Manhattan Rubber Manufacturing Division	W. L. Sturtevant
** A. W. Carpenter, Manager of Testing Laboratories	The B. F. Goodrich Co.	
* J. M. Crawford, Chief Engineer	Chevrolet Division, General Motors Corp.	C. E. Zwahl
** A. H. Flower, Technical Director	Inland Manufacturing Division, General Motors Corp.	
* W. H. Graves, Chief Metallurgist	Packard Motor Car Co.	
* C. O. Guernsey, Vice-President	J. G. Brill Co.	
* A. G. Herreshoff, Chief Engineer	Chrysler Corp.	W. J. McCortney
* W. S. James, Chief Engineer	The Studebaker Corp.	W. J. Harris
*** J. B. Johnson, Chief, Material Section, Materiel Division	Air Corps, U. S. A.	
** E. G. Kimmich, Development Engineer	Goodyear Tire and Rubber Co.	
** J. Kirschner, Chief Chemist	Dryden Rubber Co.	A. W. Robertson
** E. J. Kvet, Technical Superintendent	Baldwin Rubber Co.	Chris Kurzweil
* J. L. McCloud, Metallurgical Chemist	Ford Motor Co.	J. S. Laird
* H. M. Northrup, Chief Engineer	Hudson Motor Car Co.	J. G. Gagnon
* H. E. Simi, Chief Engineer	Twin Coach Co.	
** B. Steinfeld, Development Engineer	Republic Rubber Co.	
*** D. H. Werkenthine	U. S. Navy Dept., Bureau of Construction and Repair	
* T. P. Wright, Vice-President, Director of Engineering	Curtiss-Wright Corp.	

* Appointed by S.A.E. ** Appointed by A.S.T.M. *** Members at Large

elected chairman of the technical committee and J. D. Morron, Manager, Motor Products Div., U. S. Rubber Co., secretary.

After considerable discussion it was decided to confine the activities of the committee in the immediate future to rubber used in motor mountings and similar articles. A section consisting of Messrs. Kimmich, Allen, Morron, Flower and McCortney was appointed by the chairman to obtain from the various rubber companies data on the physical properties of rubber compounds now being supplied to the automotive industry to meet the various motor mounting specifications. It was the thought of the meeting that by analyzing these data some degree of standardization may already be in effect or, if not, the information may point the way toward desirable standardization.

Another section was authorized in the automotive industry to investigate test methods at present incorporated in motor mounting specifications so that the committee may be informed as to significant differences used by various companies in evaluating the same property. This should help to give some idea of the worth of the physical data accumulated by the first section.

At a further meeting held early in July a third section to consist of Messrs. Achterhoff, Laird, Kirchner, Kvet and Sturtevant was organized to consider classifying bumper stock.

Prominent technical authorities from various consuming and general interest groups as well as a number of rubber technologists and scientists make up the technical committee and the Society of Automotive Engineers is officially represented.

Catalogs and Literature Received

E. Leitz, Inc., 730 Fifth Ave., New York City. A 31-page folder describing the Panphot, a combined metallurgical microscope and camera. It is a combination of a metallurgical microscope, which can be converted and added to for other purposes, and a photomicrographic camera which satisfies every requirement of photomicrography and photomacrography.

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. Catalog E-33C(1), 16 pages, entitled "Mueller Bridges for Highly Precise Measurements of Temperature," describes a recently announced L&N instrument for extremely accurate calorimetric and other research work of interest to chemists, physicists, anyone interested in calorimetry and anyone interested in the latest developments of fine electrical instrumentation. Also, a five-page folder describing the Rayotube temperature detector and picturing a few of its many uses. Also, Catalog EN-95, "Apparatus for Electrolytic Conductivity Measurements in Laboratory and Plant," 40 pages. Describes and lists the latest forms of L&N apparatus for all well-established electrolytic conductivity measurements. In addition, it includes a general discussion of these measurements and illustrates suggested combinations of equipment for a proposed application.

C. J. Tagliabue Manufacturing Co., Park and Nostrand Aves., Brooklyn, N. Y. Catalog 1101D, 28 pages, describing TAG Celectray Potentiometer Pyrometers. Also, Bulletin No. 1173 describing the Celectray throttling controller which is built for rugged resistance to plant conditions, 4 pages. Bulletins Nos. 1191, 1192 and 1193, one page each, describe the Celectray multiple point indicating controller (from 3 to 6 points), Celectray multiple point indicating potentiometer, and Celectray indicating potentiometer controller (self-balancing type).

Atlas Electric Devices Co., Inc., 361 W. Superior St., Chicago, Ill. A seven-page folder entitled "Accelerated Weathering of Paints," a report by the Ontario Research Foundation of a series of weathering tests made by them. It shows the comparison between outdoor exposures and those made in the Weather-Ometer in their laboratory.

American Instrument Co., 8010-8020 Georgia Ave., Silver Spring, Md. Catalog AS15, a new 164-page catalog entitled "Instruments for Testing Cement, Soils, and Petroleum and Its Products." The Cement Section includes instruments for testing portland cement, concrete, mortar, aggregates, lime, gypsum, etc. The Soils Section deals with the testing of the mechanical stability of soils and includes latest instruments used by civil engineers and laboratories. The Petroleum Section is devoted to the testing of crude and refined petroleum, greases, etc.

E. H. Sargent & Co., 155 E. Superior St., Chicago, Ill. A six-page folder describing the improved constant temperature water bath. Also a four-page folder describing the model R.C. conductivity bridge for the measurement of resistance and electrolytic conductivity.

George Scherr Co., 128 Lafayette St., New York City. A four-page folder covering the new set of precision measuring standards under the trade name of Ultra-chex. The set consists of nine standards accurate to 8 millionths of an inch and will make 71 combinations in steps of $\frac{1}{8}$ in. up to $4\frac{7}{8}$ in. and 41 combinations in steps of .100 in. up to 4.1 in.

Parr Instrument Co., Inc., Moline, Ill. Supplement A to Direction Booklet No. 116 entitled "Directions for Using the Parr Turbidimeter, Model S3P, Photoelectric Type." The instrument described in the pamphlet may be used to measure turbidities in the range of 1 to 200 parts per million where a great deal of uncertainty has heretofore existed.

Scientific Glass Apparatus Co., Bloomfield, N. J. "Condenser News," Vol. 2, No. 1, a twelve-page booklet describing various products of this company, including: acid burette, fractionating column stedman, micro spatulas, Taylor pH comparator, vacuum distilling apparatus, reagent bottles, etc. Illustrated.

Bausch & Lomb Optical Co., 636 St. Paul St., Rochester, N. Y. Catalog D-10, 15 pages, describing various kinds of lenses, prisms and mirrors. Also, Catalog D-27, 36 pages, covering the new Bausch & Lomb Contour Measuring Projector, together with its uses.

NEW MEMBERS TO JULY 24, 1939

The following 82 members were elected from May 24 to July 24, making the total membership 4250:

Company Members (9)

AMERICAN IRON AND STEEL INST., C. M. Parker, Secretary, General Technical Committee, 350 Fifth Ave., New York City.

AMES CO., B. C., Warren Ames, President, Waltham, Mass.

AUTO SPECIALTIES MANUFACTURING CO., E. H. Grimm, Metallurgist, Graves St., St. Joseph, Mich.

DODGE STEEL CO., J. R. Baush, Sales Engineer, 6501 Tacony St., Philadelphia, Pa.

FISHER BODY DETROIT DIVISION, GENERAL MOTORS CORP., C. L. Myers, Works Engineer, General Motors Building, Detroit, Mich.

OHIO RUBBER CO., THE, M. Achterhof, Chief Chemist, Willoughby, Ohio.

PENNSYLVANIA SALT MANUFACTURING CO., E. Sweetland, Chief Chemist, Wyandotte, Mich.

RÖHREN-VERBAND G. m. b. H., Abteilung Revision, Hermann Göringstrasse 19, Düsseldorf, Germany.

ZINC DEVELOPMENT ASSN., R. Lewis Stubbs, Great Westminster House, Horseferry Road, London, S. W. 1, England.

Individual and Other Members (63)

ABBETT, R. W., Associate Engineer, Parsons, Klapp, Brinckerhoff & Douglass, 142 Maiden Lane, New York City.

ANDERSON, W. B., Chemist, Titanium Pigment Corp., 111 Broadway, New York City.

BECKWITH, B. B., Metallurgical Engineer, Vanadium Corporation of America, Detroit, Mich. For mail: 59 Oakdale Boulevard, Pleasant Ridge, Mich.

BLACKETER, C. W., Sales Engineer, Diamond Alkali Co., Pure Calcium Products Division, Box 407, Painesville, Ohio.

BOWYER, G. C., Manager, Union Concrete Pipe Co., Ceredo, W. Va.

BUFFALO SEWER AUTHORITY, Harold Epstein, General Manager, 1038 City Hall, Buffalo, N. Y.

CALDWELL, W. E., Mechanical Plant Engineer, Mechanical Engineering Dept., Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York City.

CHARLESTON, CITY OF, DEPARTMENT OF PUBLIC SERVICE, B. M. Thomson, City Engineer, Charleston, S. C.

COLLINS, W. L., Associate, Department of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

CORYELL, R. L., Assistant Engineer, Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York City.

DUBPERNELL, GEORGE, Research Engineer, United Chromium, Inc., Box 1546, Waterbury, Conn.

FLOYD, R. K., President, Frank H. Floyd, Inc., 903 W. Grand Boulevard, Detroit, Mich.

FRITZ ENGINEERING LABORATORY, Lehigh University, Bethlehem, Pa.

GALLOWAY, T. R., Structural Engineer, Mechanical Engineering Dept., Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York City.

GILT, C. M., Inside Plant Engineer, Electrical Engineering Dept., Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York City.

GLAESER, FRED, Engineer's Assistant, Gas Maintenance-Construction Dept., Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York City.

GOETZ, A. C., Manager, Technical Service Dept., Pigment Division, The Eagle-Picher Sales Co., Temple Bar Building, Court and Main Sts. Cincinnati, Ohio.

GROVER, LAMOTTE, Structural Welding Engineer, Applied Engineering Dept., Air Reduction Sales Co., 60 E. Forty-second St., New York City.

HANSEN, S. S., Chief Lubricating Engineer, General Petroleum Corp., 108 W. Second St., Los Angeles, Calif.

HENDREN, J. T., Chief Chemist, Pan American Airways, Miami, Fla. For mail: 7711 N. W. Thirteenth Court, Miami, Fla.

HOUSING AUTHORITY OF THE BIRMINGHAM DISTRICT, D. W. Bateman, Consulting Engineer, Box 37, Birmingham, Ala.

HOUCK, C. M., Vice-President, Pittsburgh Testing Laboratory, Box 1646, Pittsburgh, Pa.

HOWITZ, C. R., Petroleum Inspector, Sun Oil Co., Marcus Hook, Pa. For mail: 201 Parkway Ave., Chester, Pa.

HOYT, L. F., Research Chemist, Application Research Division, National Aniline and Chemical Co., 351 Abbott Road, Buffalo, N. Y.

INDIAN JUTE MILLS ASSN., W. G. Macmillan, Chief Chemist, Research Dept., 16 Old Court House St., Calcutta, India.

JOHNSON, M. W., Manager, St. Louis Office, Pittsburgh Testing Laboratory, 4573 Chouteau Ave., St. Louis, Mo.

JONES, A. R., Division Engineer, New York Central Railroad Co., 35 N. Pine Ave., Albany, N. Y.

KEELY, E. M., General Superintendent, Petty Island Plant, Cities Service Oil Co., Allegheny Ave. Wharf, Philadelphia, Pa.

KREAMER, J. C., II, Plant Chemist, Ogden Plant, Container Corporation of America, Chicago, Ill. For mail: 746 Elm St., Glen Ellyn, Ill.

LAYTON, W. M., Material and Process Engineer, Westinghouse Electric and Manufacturing Co., Mansfield, Ohio. For mail: 38 Wellington Ave., Mansfield, Ohio.

LEFEVRE, G. HOWARD, Metallurgist, United States Smelting, Refining and Mining Co., 1600 Wadsworth Building, 57 William St., New York City.

LINDSTROM, A. L., Consulting Mechanical Engineer, 706 Mortgage Guarantee Building, Atlanta, Ga.

LONG, L. H., Superintendent, Atlas Foundry and Machine Co., Box 1606, Tacoma, Wash.

LOUBSER, M. J., Chief Mechanical Engineer, South African Railways and Harbours, Pretoria, South Africa.

LUSSKIN, ABRAHAM, Chemist, Everseal Manufacturing Co., Inc., Ridgefield, N. J.

MAESER, MIETH, Materials Engineer, United Shoe Machinery Corp., Beverly, Mass. For mail: 65 Baker Ave., Beverly, Mass.

MCCLAIN, J. R., Materials and Process Engineer, Westinghouse Electric and Manufacturing Co., Sharon Works, Sharon, Pa. For mail: 83 Jefferson Ave., Sharon, Pa.

MILNE, G. R., Outside Plant Engineer, Electrical Engineering Dept., Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York City.

MELSHEIMER, L. A., Chemist, Sales Technical Service, United Color and Pigment Co., Division of Interchemical Corp., McClellan St., Newark, N. J.

MERRILL, D. H., Structural Engineer, 2404 W. Seventh St., Los Angeles, Calif.

MOORE, HAROLD, Director, British Non-Ferrous Metals Research Assn., Euston St., London, N. W. 1, England.

MORRON, J. D., Manager, Motor Products Development, United States Rubber Co., Detroit, Mich. For mail: 1386 Kensington Road, Grosse Pointe, Mich.

MOUNT, R. H., Assistant to the President, Essex Wire Corp., 14310 Woodward Ave., Detroit, Mich.

ONDERDONK, P. T., Inspection Engineer, Contract Control and Inspection Dept., Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York City.

OWEN, A. E., Chief Engineer, Reading Co., Reading Terminal, Philadelphia, Pa.

PACIFIC COAST BUILDING OFFICIALS CONFERENCE, Hal Colling, Secretary to the Executive Committee, 124 W. Fourth St., Los Angeles, Calif.

PERRY, H. H., General Manager, Electric Wheel Co., Quincy, Ill.

SCHIEFER, H. F., Physicist, National Bureau of Standards, Washington, D. C.

SCHMIED, O. K., Chief Chemist, Reynolds Metals Co., Central Ave., South Kearney, N. J.

SCHWARTZ, CHARLES, Chemist, Calgon, Inc., 300 Ross St., Pittsburgh, Pa.

SHIELDS, A. L., Materials and Process Engineer, Westinghouse Electric and Manufacturing Co., 653 Page Boulevard, Springfield, Mass.

SHIELDS, C. E., Vice-President, Petroleum Heat and Power Co., Stamford, Conn.

SMITH, G. FREDERICK, Associate Professor of Chemistry, University of Illinois, Urbana, Ill. For mail: Box 87, Urbana, Ill.

SPEARING, C. E., Petroleum Technologist, Anglo-Iranian Oil Co., Ltd., c/o W. D. Brown, 620 Fifth Ave., New York City.

STANDING, S. A., Materials Engineer, Raytheon Production Corp., 55 Chapel St., Newton, Mass.

THRASHER, G. M., Metallurgist, Eastern Sales and Service, R. Lavin and Sons, Inc., Chicago, Ill. For mail: 752 Robinson St., Elmira, N. Y.

THURSTON, R. R., Supervisor, Asphalt and Roofing Products, The Texas Company, Technical and Research Division, 135 E. Forty-second St., New York City.

VIOHL, H. K. W., Assistant Chief Engineer, Benjamin F. Shaw Co., Wilmington, Del.

WILSON, R. L., Metallurgical Engineer, Climax Molybdenum Co., 1101 First National Bank Building, Canton, Ohio.

WHIRL, S. F., Chief Chemist, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.

WORTHINGTON, J. G., Chief Metallurgist, J. D. Adams Manufacturing Co., 217 S. Belmont, Indianapolis, Ind.

YOST, E. N., Chief Inspector, Gary Works, Carnegie-Illinois Steel Corp., Gary Ind. For mail: Chesterton, Ind.

YOUNG, EDWIN, Chief Draftsman and Specification Writer, Massena & duPont, 704 Delaware Ave., Wilmington, Del.

Junior Members (10)

BARRACLOUGH, K. C., Analyst, Steelworks Research, The Brown-Firth Research Laboratories, Sheffield, England. For mail: 19 Park Ave., Chapeltown, Sheffield, England.

CRANE, L. S., Chemist, Procurement Division, U. S. Treasury Dept., Washington, D. C. For mail: 5425 Connecticut Ave., Washington, D. C.

ERICKSON, H. J., Chief Chemist, Keystone Oil Refining Co., 12800 Northampton St., Detroit, Mich.

FRASER, E. S., Erection Engineer, Chicago Bridge and Iron Co., Chicago, Ill. For mail: 11080 Esmond St., Chicago, Ill.

HARMAN, W. H., JR., Testing Machine Division, Baldwin-Southwark Corp., Eddystone, Pa. For mail: 4900 Woodland Ave., Drexel Hill, Pa.

MUNGER, W. P., IV, Assistant Designing Engineer, American Nepheline Corp., Rochester, N. Y. For mail: 1330 Park Ave., Rochester, N. Y.

PONS, P. A., Engineer in Charge of Testing Materials, Division of Survey and Construction of Highways, Roads and Bridges, Department of the Interior of Puerto Rico, San Juan, Puerto Rico. For mail: 54½ Ponce de Leon Ave., Santurce, Puerto Rico.

RANDALL, J. F., Welding Engineer, Combustion Engineering Co., Inc., 200 Madison Ave., New York City.

SHIRK, F. K., Research Engineer, Penn Worsted Co., Philadelphia, Pa. For mail: 527 Turner St., Philadelphia, Pa.

WALKER, J. W., Principal Walker Laboratory, 1209 Rice St., Columbia, S. C.

PERSONALS

. . . News items concerning the activities of our members will be welcomed for inclusion in this column.

G. G. BROWN, Professor of Chemical Engineering, University of Michigan, was awarded the 1939 William H. Walker Medal of the American Institute of Chemical Engineers at its meeting in Akron, Ohio. The medal is awarded annually for an outstanding contribution to chemical engineering literature.

G. A. LUX has left his position as Chief Chemist, General Railway Signal Co., to assume the duties of Technical Director at the Lustre Chemical Corp. in Rochester, N. Y.

F. A. PRISLEY, formerly Chemist, Wanskuck Co., Providence, R. I., is now Chemist, Hayward-Schuster Woolen Mills, Chemical Division, East Douglas, Mass.

F. C. FRARY, Director of Research, Aluminum Company of America, will receive the 1939 Edward Goodrich Acheson Gold Medal and $1000 prize from the Electrochemical Society at the fall meeting of the Society. The award is made for distinguished contributions to the electrometallurgy of aluminum as well as to other scientific fields.

ALFRED SUGAR is now Metallurgist, Monarch Aluminum Manufacturing Co., Cleveland, Ohio. He was formerly Metallurgist, U. S. Reduction Co., East Chicago, Ind.

W. A. WESLEY, Assistant Director, Research Laboratory, International Nickel Co., Bayonne, N. J., was awarded the American Electro-Platers' Society's annual gold medal at its twenty-seventh annual convention in Asbury Park, N. J., recently, in recognition of his paper on "Physical Properties and Uses of Heavy Nickel Deposits."

JOSEPH MARIN, formerly Assistant Professor of Engineering Materials, College of Engineering, Rutgers University, is now Associate Professor of Civil Engineering, Armour Institute of Technology, Chicago, Ill.

G. M. GOODSPEED, who was Metallurgist, National Works, National Tube Co., McKeesport, Pa., has now retired.

R. Z. DRAKE, formerly Bridge Engineer and Builder, S. G. Hunter Iron Works Co., Omaha, Nebr., is now Bridge Engineer and Lumber Cold Sesoner, Standard Sesoning Society, Omaha, Nebr.

D. M. WALSH, who was Refinery Superintendent, Trinidad Central Oilfields, Ltd., Tabaquite, Trinidad, B.W.I., is now with Masons, Ltd., Port of Spain, Trinidad, B.W.I.

G. W. MOREY, Geophysical Laboratory, Carnegie Institution of Washington, and chairman of the Society's Committee C-14 on Glass and Glass Products, was awarded the Honorary Degree of Doctor of Science by the New York State College of Ceramics at Alfred University, presentation of Doctor Morey being made by another A.S.T.M. member, M. E. Holmes, Dean of the College. Dean Holmes pointed out it was fitting that Alfred University, operating as it does a Department of Glass Technology, should recognize the outstanding scientific work of Doctor Morey, much of which has been in the field of glass and glass products.

H. L. DOTEN, formerly Construction Engineer, Maine State Highway Commission, Bridge Division, is now Business Manager, University of Maine, Orono, Me.

F. D. KLEIN, JR., is at present connected with The Sherwin-Williams Co., Aviation Department, Chicago, Ill. He was formerly Director of Technical Sales, The Schaefer Varnish Co., Louisville, Ky.

RICHARD RIMBACH has been appointed Technical Advisor to R. C. Enos, President of Standard Steel Spring Co., Coraopolis, Pa.

The Institute of British Foundrymen, hosts at the International Foundry Congress, held in London, June 12 to 16, honored H. A. SCHWARTZ, Manager of Research, National Malleable and Steel Castings Co., Cleveland, Ohio, with the award of the E. J. Fox Gold Medal for his contribution to the manufacture of malleable castings. This is the first time the medal has been awarded to anyone outside Britain.

G. W. HUTCHINSON, formerly Technical Representative (Concrete), Appalachian Electric Power Co., Dublin, Va., is now Concrete Technician, American Gas and Electric Co., Raleigh, N. C.

L. J. BRIGGS, National Bureau of Standards, Washington, D. C., has been elected a Fellow in mathematical and physical science of the American Academy of Arts and Sciences.

DOUGLAS DOW replaces C. F. Hirshfeld, deceased, as Chief of Research with The Detroit Edison Co.

H. P. BOARDMAN, who was Professor of Civil Engineering, and Director, Engineering Experiment Station, University of Nevada, Reno, Nev., has retired.

P. H. BATES, Chief, Clay and Silicate Products Division, National Bureau of Standards, Washington, D. C., has been awarded the Turner Gold Medal of the American Concrete Institute. The award was made for contributions to science, direction of research and outstanding leadership in advancing the intelligent utilization of cement and concrete.

F. M. FARMER, Vice-President and Chief Engineer, Electrical Testing Laboratories, New York City, was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1939, as announced at the annual meeting of the Institute held in San Francisco, Calif.

F. T. LLEWELLYN, who retired June 1 as Research Engineer, United States Steel Corp. of Delaware, after nearly 50 years' service with the corporation, was presented, upon the eve of his retirement from business, with an engrossed resolution of appreciation for his contribution to the structural steel fabricating industry by the American Insitute of Steel Construction.

E. B. WHITMAN, Consulting Engineer, Whitman, Requardt & Smith, Baltimore, Md., was recently appointed to the chairmanship of the Maryland State Highway Commission.

ALBERT HAERTLEIN, Associate Professor of Civil Engineering, Graduate School of Engineering, Harvard University, has been elected secretary of the Engineering Societies of New England for the year which began on June 1.

ZAY JEFFRIES, Technical Director, Incandescent Lamp Dept., General Electric Co., Nela Park, Cleveland, Ohio, has been elected to membership in the National Academy of Sciences, membership of which is limited to 350 members. Membership is recognized as one of the highest scientific honors.

V. L. SMITHERS, President, V. L. Smithers Laboratories, Akron, Ohio, was recently appointed Commissioner of the National Battery Manufacturers Assn., Inc. His headquarters will be in the First Central Tower, Akron.

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Professional Cards will be accepted for inclusion on this page from Consulting Engineers, Metallurgists, Chemists, Testing Engineers and Testing Laboratories

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